A COMPARATIVE ANALYSIS OF LAKE HURON PHYTOPLANKTON ASSEMBLAGES AFTER ENTRAINMENT AT SELECTED WATER INTAKE FACILITIES

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ABSTRACT

The current study was undertaken to evaluate the feasibility of establishing an inexpensive long-term surveillance monitoring program for Lake Huron, sampling from selected water treatment plant intakes. Phytoplankton samples were collected from two water treatment facilities (Port Huron and Alpena) during three different seasons of the year. For each season a time series of 6-12 samples was taken over a 24-hr period above each intake crib (lake samples). Paired samples were collected after an appropriate lag time from the intake pipe inside each plant (tap samples). Differences in taxon densities due to lake/tap effects were, in general, small compared to differences due to season or location. Some significant differences in taxon density were found between lake and tap samples, but the nature of the lake/tap effect was not consistent across season, location, or taxon. Port Huron tap samples from summer and spring showed a consistent (though not always statistically significant) decrease in abundance of several flagellated taxa. Flagellate density decreased significantly in Alpena winter tap samples; Alpena summer tap samples contained consistently higher densities of benthic taxa.

This preliminary study suggests that certain characteristics of the intake may be important if a water treatment facility is to be useful for long-term monitoring:

(1) entrainment either does not significantly change, or changes in a consistent predictable fashion, the phytoplankton populations of interest;

(2) the water around the intake is representative of the body of water being monitored;

(3) the phytoplankton assemblage responds conservatively to short-term environmental perturbations and long-term seasonal changes;

(4) intake depth does not force the sampling of a different assemblage when lake level or the season changes.

The preliminary data indicate that a carefully and thoughtfully designed intake sampling program could be a powerful tool for monitoring Great Lakes water quality.

ACKNOWLEDGMENTS

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INTRODUCTION

Quantitative and qualitative changes in the biota of the Laurentian Great Lakes have been observed at several trophic levels (Carr and Hiltunen 1965; Stoermer and Yang 1969; McNaught and Buzzard 1973; Christie 1974). Many of the changes have been interpreted as signs of accelerated anthropogenic eutrophication of the system (Beeton 1965; Patalas 1972; Smith 1972; Stoermer 1978). Early detection of such trends and implementation of appropriate management strategies can minimize deleterious effects on the commercial and recreational potential of the lakes.

Since phytoplankton assemblages occupy the interface between the physical/chemical environment and higher trophic levels, analyses of phytoplankton assemblage composition have frequently been used to monitor water quality (Stoermer 1978). Several different monitoring strategies have been used to track population shifts across time: comparison of historic records and/or samples with present day material from similar locations (Hohn 1969; Stoermer and Yang 1969); examination of core samples or other fossil records (Duthie and Sreenivasa 1971; Frederick 1981); and continuous long-term surveillance at a given site (Davis 1964; Hohn 1969; Nicholls et al. 1977, 1980). Continuous long-term surveillance has the advantage of integrating short-term patchiness and seasonal fluctuations over time and also provides a continuous historical record against which to evaluate current observed changes.

Continuous surveillance was particularly useful in documenting recent changes in the biota of Lake Erie (Davis 1964; Verduin 1964; Nicholls et al. 1977, 1980). Many of these surveillance studies have involved analysis of samples obtained from water treatment plant

intakes, e.g. in Lake Erie (Davis 1964; Verduin 1964; Nicholls et al. 1977,1980), in Lake Ontario (Schenk and Thompson 1965), in Lake Michigan (Damman 1966; Vaughn 1970; Danforth and Ginsburg 1980). Continuous surveillance studies of similar duration have not been conducted in Lake Huron. Existing treatment plant daily records from the Bay City water intake in Saginaw Bay for the period 1962-1976 were examined by Goodell (1977). Short-term studies were carried out from 1959-1962 in the St. Clair River at the outlet of Lake Huron (Williams and Scott 1962), at the Midland water intake at Whitestone Point in Saginaw Bay from 1973-1975 (Chartrand 1975), and in Georgian Bay from 1973-1974 (Nicholls et al. 1975). Quantitative lakewide phytoplankton studies were only recently published for Lake Huron (Schelske et al. 1974; Lowe 1976; Stoermer et al. 1976; Stoermer and Kreis 1980).

The current study was undertaken to evaluate the feasibility of establishing an inexpensive long-term surveillance monitoring program for Lake Huron, sampling from selected water treatment plant intakes. Nicholls (1981) discusses several anomalies found in water intake datasets and suggests that factors such as proximity to a river plume and fluctuating lake water levels may add unexplained variance to water intake samples. However, we have been unable to find a study in the literature that tests the more basic question of whether significant differences exist between phytoplankton assemblages found in the open lake and those found in water entrained in a treatment plant. This study was designed to test the following basic questions related to water intake sampling:

1) Does entrainment in a water treatment plant systematically alter a lake phytoplankton assemblage either qualitatively or quantitatively?

2) Does the nature and magnitude of any observed effect change with (a) the sampling site, since physical characteristics of the intake differ from plant to plant (e.g. length and diameter of the pipe, crib distance from shore, crib depth, residence time in the pipe, etc.); or (b) the season of the year, because assemblage composition and plankton vertical distribution change across seasons?

MATERIALS AND METHODS

Water samples from Lake Huron were collected at two selected water treatment facilities (Port Huron, Alpena (Fig. 1)) by the staff of the Michigan Department of Natural Resources. Their experimental design (Table 1) included sampling at each of the facilities during three different seasons of the year. For each season a time series of 6-12 samples was taken over a 24-hr period, using a 4-liter Van Dorn sampler lowered to a depth 1 m above each intake crib (lake samples). Paired samples were taken from the intake pipe inside each plant (tap samples) at the same time intervals as outside, but sampling was delayed by the estimated pipe transit time for a slug of lakewater. Approximate lag times were 8 hr 45 min for Port Huron and 30 to 60 min for Alpena, depending on the plant pumping rate at the time of sampling. A limited number of "replicate" samples were taken 15 to 30 minutes apart at each sampling site. Since these samples were not true replicates, but simply samples taken at slightly shorter time intervals than "non-replicates," they were treated in the statistical analyses as additional points in

Fig. 1. Map of Lake Huron locating the water treatment plant intake cribs where samples were taken.

Location	Lat-Lon	Crib Depth	Crib Distance Offshore	Intake Pipe Diameter
Port Huron	43°07'34" 82°23'29"	45 ft	5 mi	16 ft
Alpena	45°02'38" 83°26'20"	16 ft	2,000 ft	3 ft

TABLE 1. Sampling design.

Water intake	Season	Sampling date	Number of samples taken in 24 hr
Port Huron	Summer	8 Aug 1980	Lake - 12 Tap - 12
	Fall	7 Oct 1980	Lake - 3 Tap - 10
	Spring	18 May 1981	Lake - 6 Tap - 6
Alpena	Summer	25 Aug 1980	Lake - 12 Tap - 12
	Fall	14 Oct 1980	Lake - 12 Tap - 12
	Winter	9 Feb 1981	Lake - 6 Tap - 6

the time series rather than as replicates. A complete set of lake samples was not obtained for Port Huron during the fall; therefore this subset of the data was not included in the statistical analyses.

Whole water samples (500 mL) were preserved in Lugol's iodine solution. A 25-mL subsample for quantitative enumeration was filtered through a 0.8 μm 25 mm AA Millipore membrane filter and dehydrated through an increasing concentration ethanol series. Semi-permanent slides were made by embedding the filter in clove oil on a 50x75 mm glass slide.

Leitz Ortholux research microscopes rendering a magnification of 900X with a numerical aperture of 1.32 were used for identification and enumeration. Population estimates were calculated from two 10 mm strip counts across the effective filtration diameter.

STATISTICAL METHODS

Raw data from bench sheets were encoded and computer-processed using the taxonomic database management system FIDO, designed and maintained by staff at Great Lakes Research Division. The database management system provides an interface to the MIDAS statistical programs of the University of Michigan's Statistical Research Laboratory, which were used for all statistical analyses. Tabulations of the processed data as produced by FIDO are included in Appendix III.

To minimize noise problems in the data, to minimize skewness due to large numbers of zeros, and to maximize power in multiple univariate tests, only those taxa which satisfied the following criteria were used: selected taxa (1) were present on at least 2/3 of the slides counted for each location, season and sampling site, and (2) had a maximum occurrence of at least 10 individuals for singly-occurring taxa or

10 colonies for colonial forms. Due to the small volume of water sampled, taxa of completely indeterminant colony size (e.g. *Fragilaria crotonensis*, *Anacystis incerta*) were not included in the statistical analyses.

Individual taxa cell densities from the lake/tap paired samples were compared using both univariate paired sample t-tests (parametric) and pairwise Wilcoxon rank sum tests (nonparametric). Type I error was controlled in the simultaneous univariate t-tests using the Bonferroni critical value $t_{\alpha/p;N-1}$, where p = the number of simultaneous t-comparisons made on a single dataset (Morrison 1976). Hotelling's T-square statistic (Morrison 1976), the multivariate analog of the univariate t-statistic, was used to test for significant multivariate differences between the paired lake/tap vectors of cell densities. The use of Hotelling's T-square circumvents the problem of controlling α when performing simultaneous univariate t-comparisons on the same data set, but the requirement of multivariate normality is more stringent than the assumptions required for the univariate t-test. Multivariate similarities among samples were summarized graphically using principal component analysis. The correlation matrix was used in the PCA; variables corresponded to taxa or division densities, cases to lake/tap samples, i.e. a sample was located in n-dimensional space on the basis of the cell densities of n different taxa observed there (Stoermer et al. 1976, 1978).

Many of the statistical analyses used assume univariate or multivariate normality and homoscedasticity. Interpretation of the statistical results should be tempered by the fact that biological data in general, and phytoplankton enumeration data in particular, often do

not conform well to either of these assumptions. The analyses used are considered to be robust, in general, to moderate deviations from these assumptions (e.g. Remington and Schork 1970).

RESULTS - DESCRIPTIVE

Absolute abundance of selected phytoplankton taxa from Port Huron and Alpena lake/tap samples is plotted as a function of season in Figures 2 and 4 respectively; seasonal trends based on divisional percent composition are presented in Figures 3 and 5.

Port Huron lake and tap samples showed a similar seasonal trend in total abundance; however, tap samples in general had slightly lower mean values (Fig. 2a). Total density showed slight peaks during the summer and spring with lowest values during the fall. Mean cell densities ranged from a maximum of 1,936 cells/mL (lake) and 1,930 cells/mL (tap) in the spring to 1,194 cells/mL (lake) and 843 cells/mL (tap) in the fall.

Port Huron lake and tap samples also showed similar seasonal patterns in assemblage composition (based on divisional percentages (Figs. 3a,b)). Diatom assemblages were dominant at Port Huron for all time periods sampled. *Cyclotella comensis* (Fig. 2g) was the dominant during the summer and fall whereas *Fragilaria capucina* dominated during the spring in both lake and tap samples. Diatom populations contributed from 47% (lake) in the summer to 73% (tap) of the assemblage in the spring. Slightly higher mean diatom densities were observed in Port Huron tap samples for all seasons (Fig. 2b).

Blue-green algae reached their highest relative abundance in the fall samples (Figs. 3a,b). The dominant taxa were *Gomphosphaeria lacustris* and *Anacystis incerta*, which form large colonies of

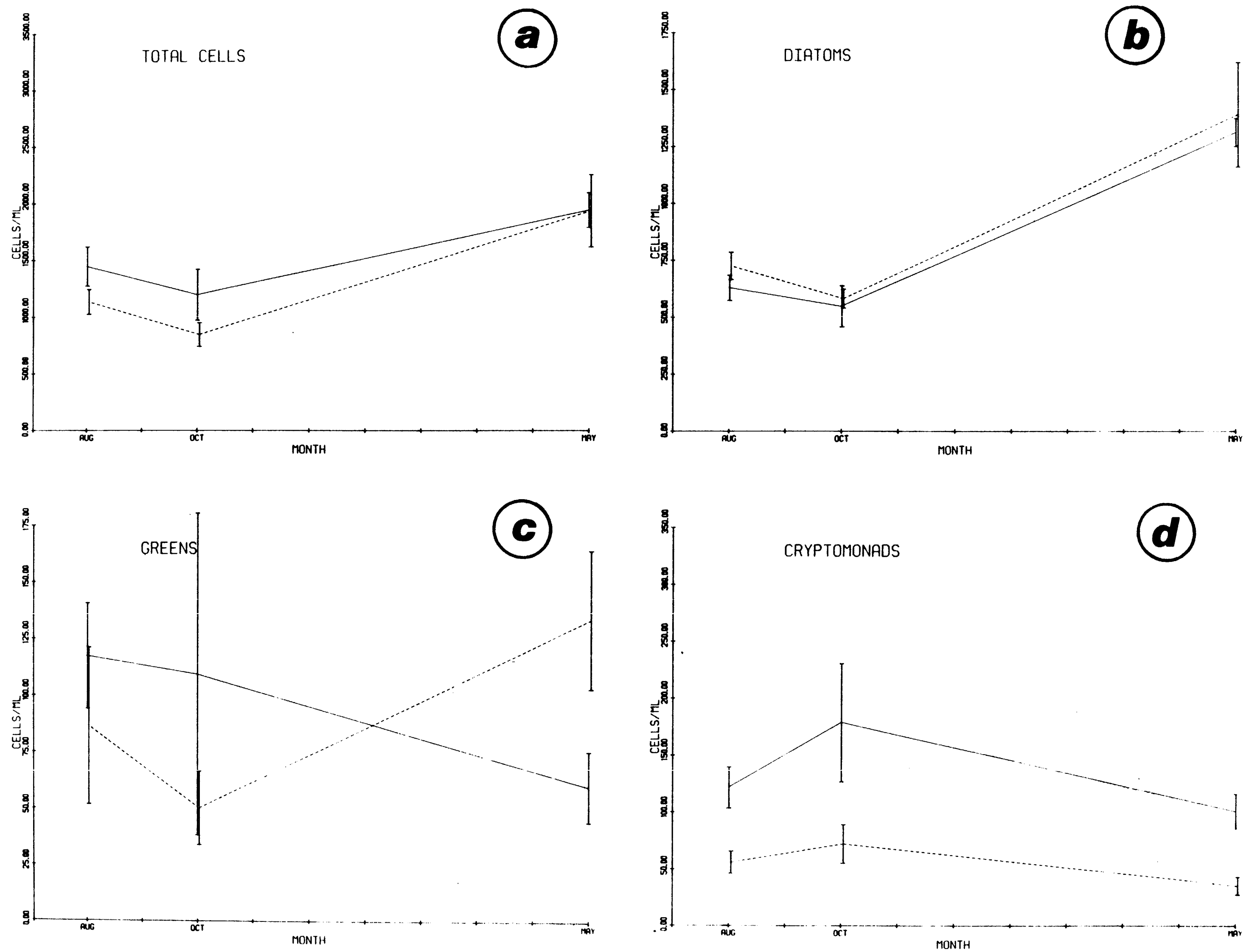
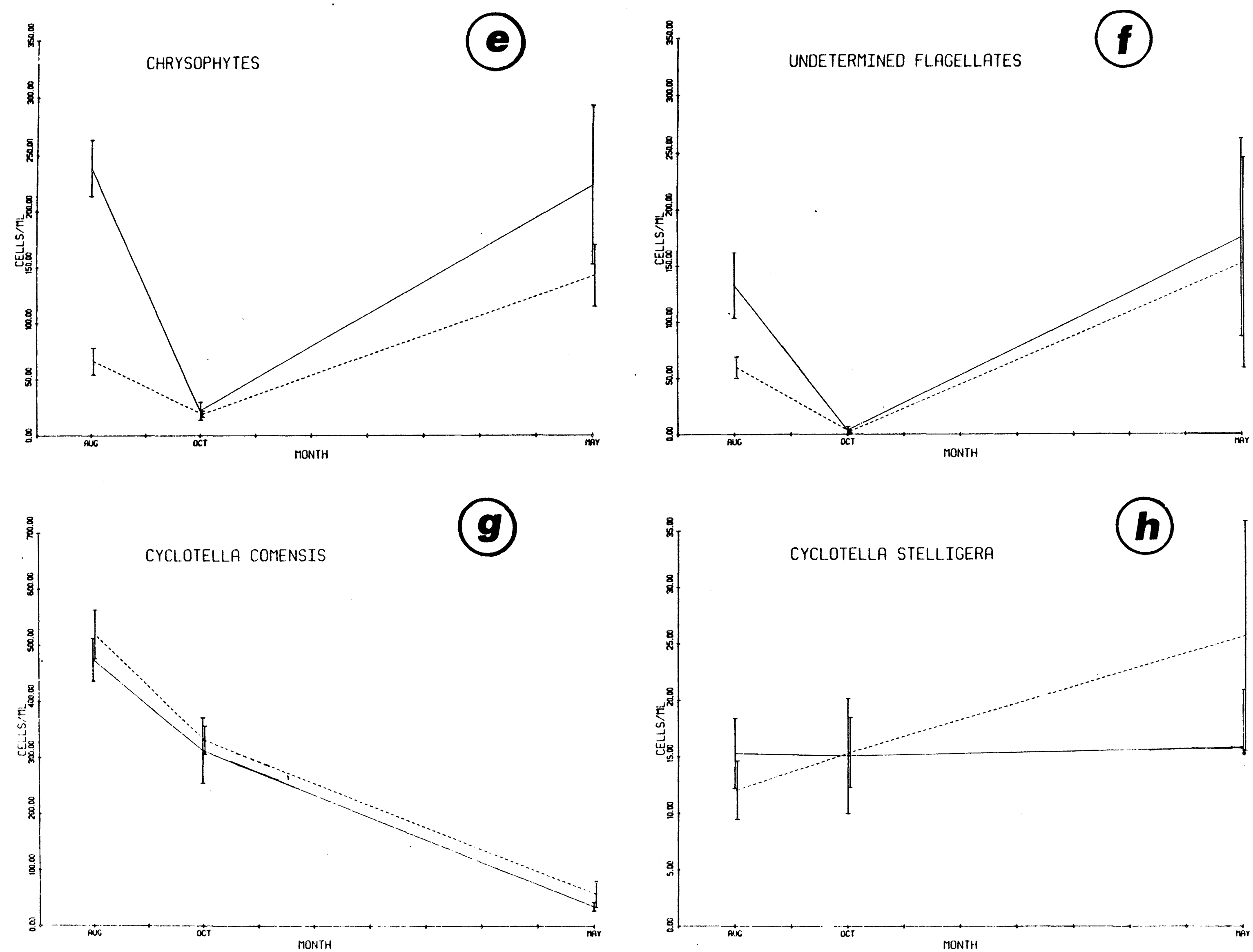


Fig. 2a-k. Port Huron. Mean cell densities (cells/mL) of selected taxa as a function of season. Solid line = lake abundance; dashed line = tap abundance. Error bars represent ± 1 standard error of the mean. Note that means describing the fall lake samples were calculated from a very small sample size (N = 3).



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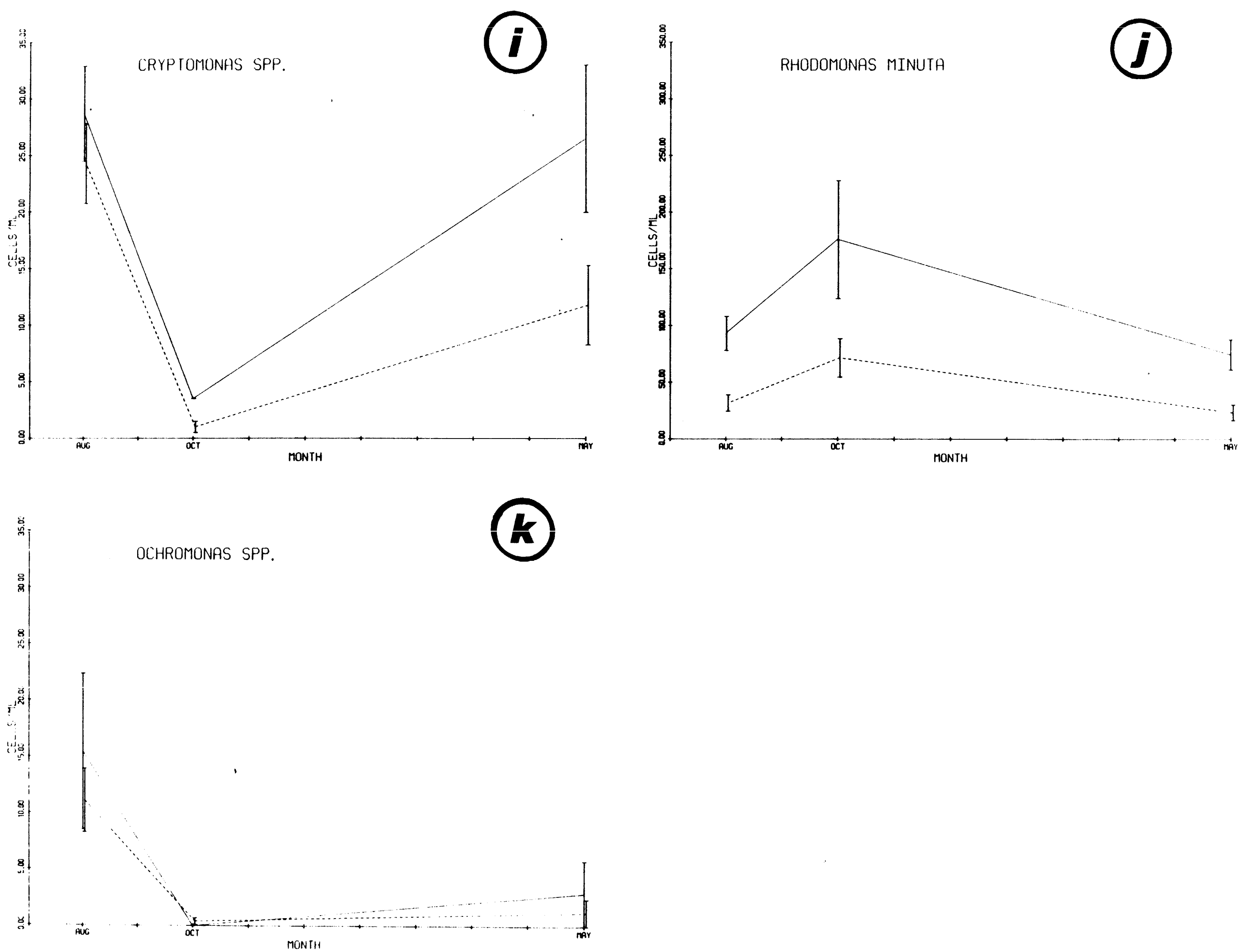

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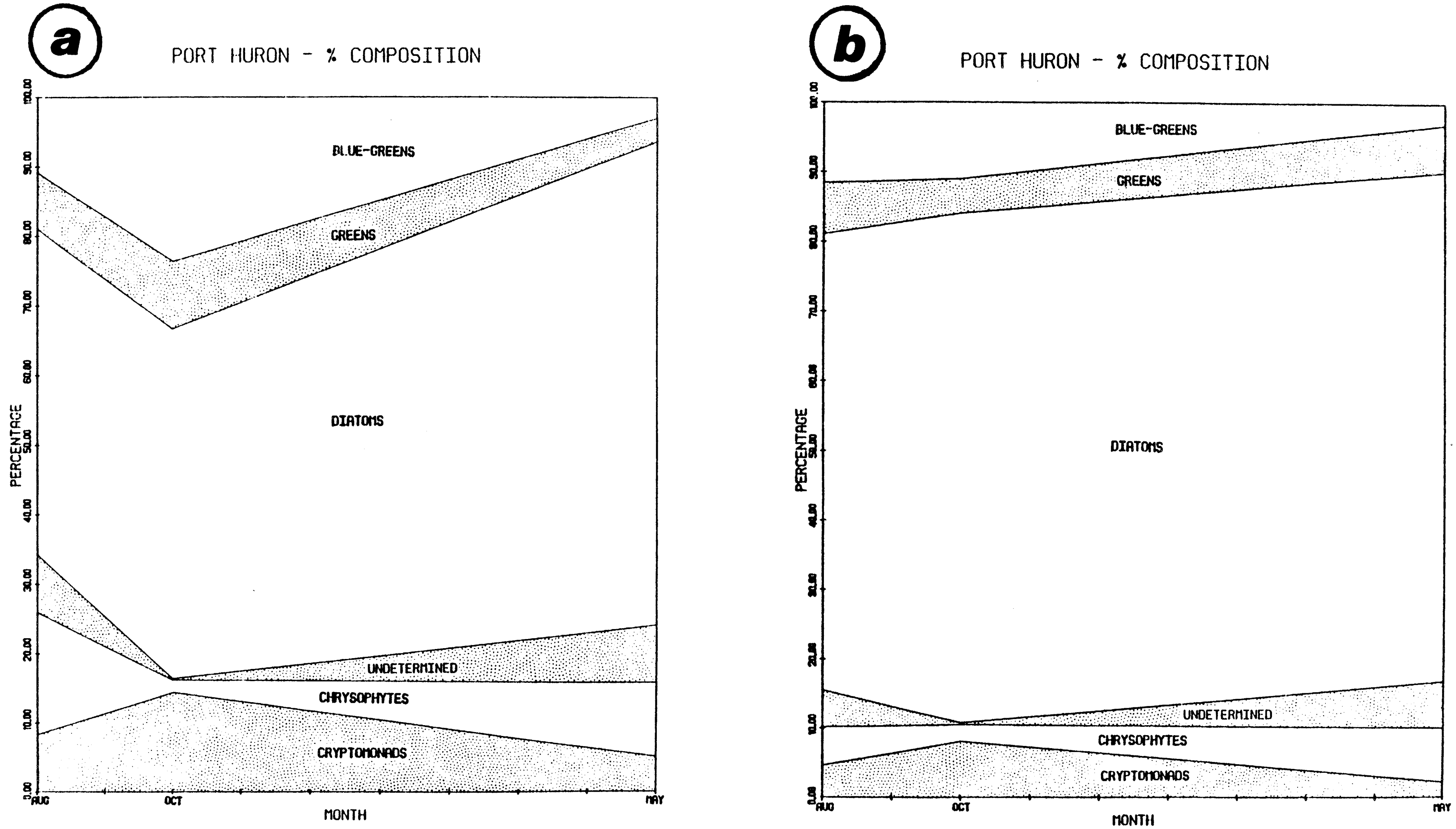


Fig. 3. Port Huron. Mean percent composition of major divisions as a function of season. Note that means describing fall lake samples were calculated from a very small sample size (N = 3). (a) Lake samples. (b) Tap samples.

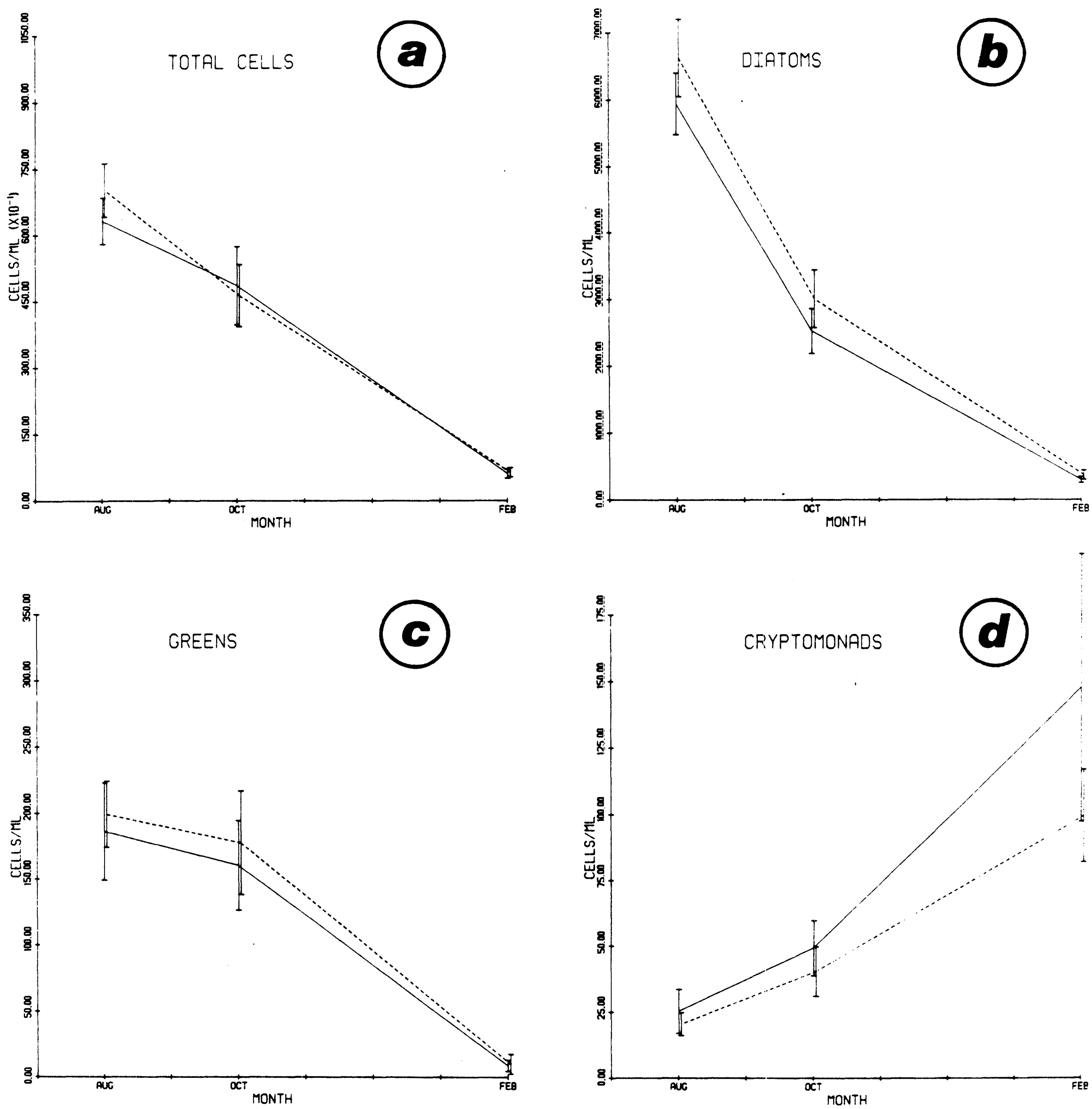
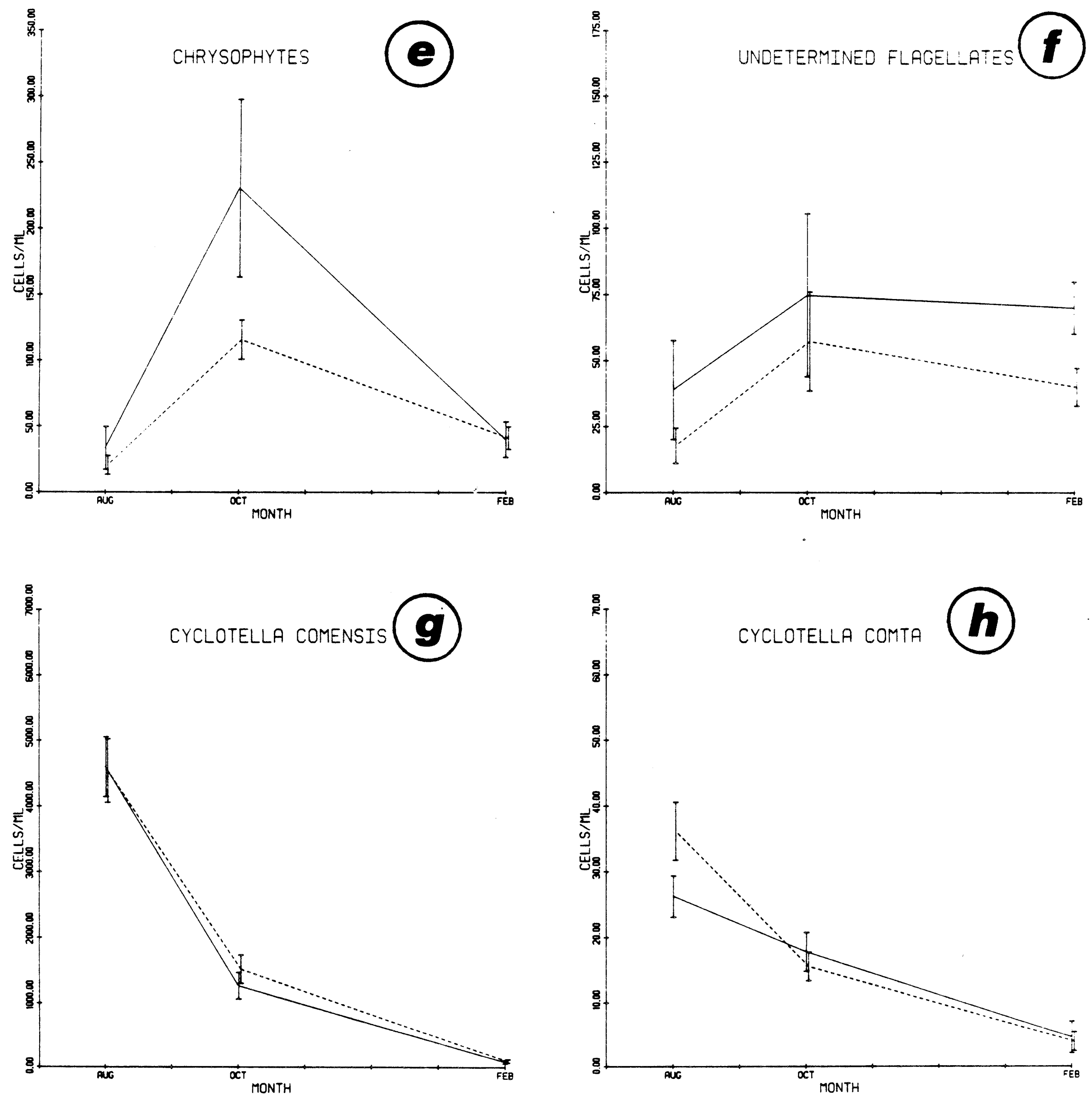


Fig. 4a-*l*. Alpena. Mean cell densities (cells/mL) of selected taxa as a function of season. Error bars represent $\pm$ 1 standard error of the mean. Solid line = lake abundance; dashed line = tap abundance.



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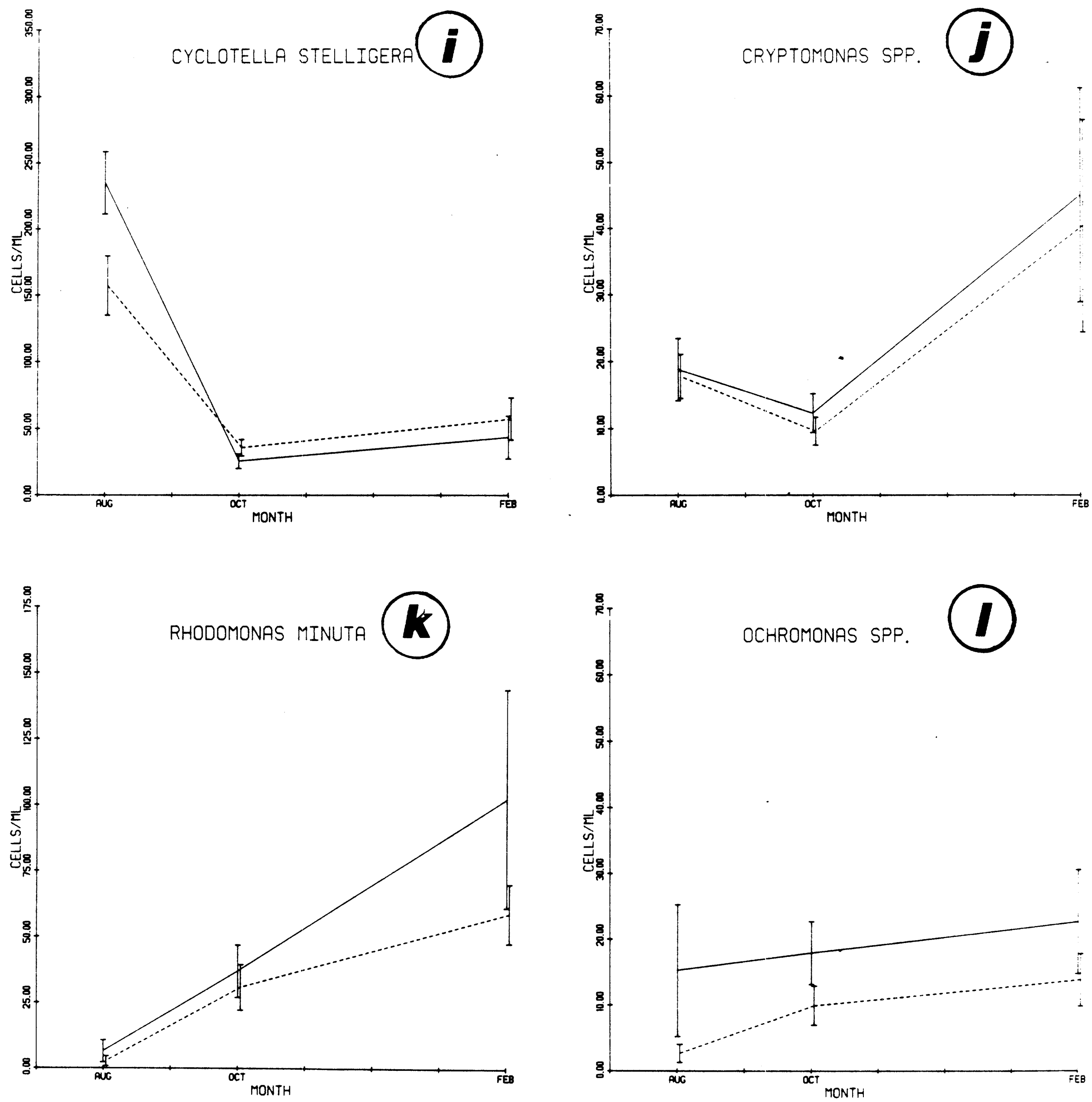

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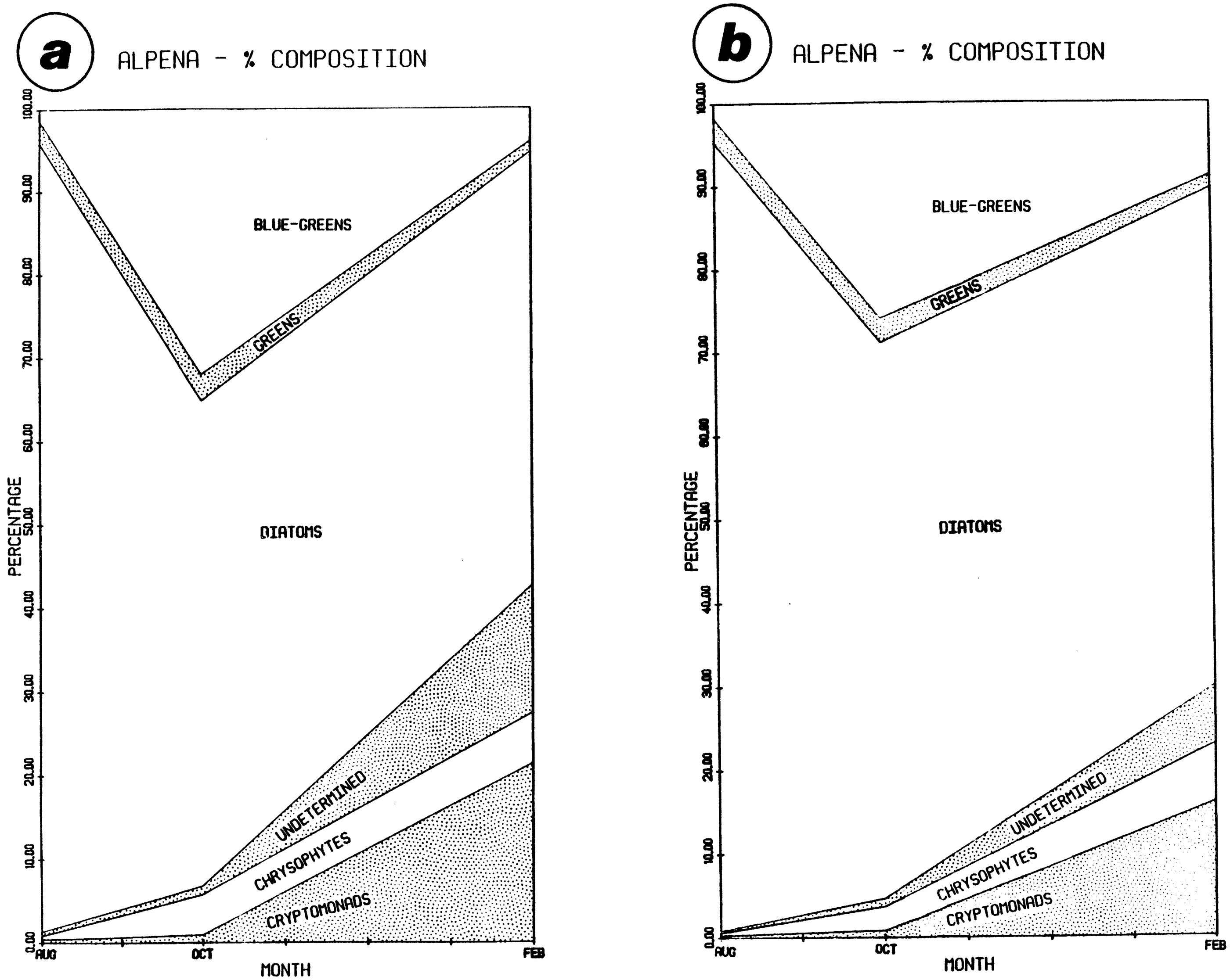


Fig. 5. Alpena. Mean percent composition of major divisions as a function of season. (a) Lake samples. (b) Tap samples.

indeterminant and highly variable size. As a result, the sometimes large blue-green densities observed corresponded to very small numbers of independent colony counts and cannot be considered reliable estimates of the blue-green populations. Accurate estimation of such highly colonial (or rare) populations would require a stratified counting procedure that scanned a volume of water for each taxon which was inversely proportional to its colony abundance. Green algae, largely composed of *Gloeocystis planctonica*, contributed less than 10% of the assemblages in all cases and showed no consistent lake/tap effect across seasons (Fig. 2c).

Cryptomonads (Fig. 2d), dominated by *Rhodomonas minuta* (Fig. 2j), showed maximum abundance in October (contributing 14% of the assemblage). Chrysophytes (Fig. 2e) and the undetermined group (predominantly flagellates) (Fig. 2f) showed peaks in the summer and spring in both lake and tap samples. Chrysophytes were represented by *Chrysosphaerella longispina* and *Ochromonas* spp. (Fig. 2k) in the summer and *Dinobryon divergens* in the spring. Such flagellated groups in general showed consistently lower abundances in the tap samples across all seasons.

Lake and tap samples from Alpena showed similar seasonal patterns in total abundance (Fig. 4a). Summer samples had the greatest total cell densities, with decreasing abundance through the fall and winter. Mean cell densities ranged from 6,325 cells/mL (lake) and 7,019 cells/mL (tap) in the summer to 604 cells/mL (lake) and 635 cells/mL (tap) in the winter.

Lake and tap samples at Alpena were dominated by diatom populations through all seasons sampled (Figs. 5a,b). Diatoms comprised between 52%

(lake) of the assemblage in the winter to 95% (lake) in the summer. *Cyclotella comensis* (Fig. 4g) was the most abundant; *Fragilaria crotonensis* and *Cyclotella stelligera* (Fig. 4i) were subdominants. Similar to the result described above for Port Huron, slightly higher mean diatom densities were observed in the tap samples for all seasons (Fig. 4b).

The blue-green algae reached peak abundance in October (comprising 32% (lake) of the assemblage) (Figs. 5a,b) and were again dominated by *Anacystis incerta* and *Gomphosphaeria lacustris*, the same highly colonial taxa found at Port Huron. As discussed above for Port Huron, the observed densities corresponded to a very small number of independent colony counts and may not provide an accurate estimate of blue-green abundance. Green algae showed maximum cell densities in the summer (Fig. 4c), but never comprised more than 5% of the assemblage; lake and tap samples exhibited very similar trends with season. Chrysophytes (Fig. 4e) and the undetermined group (Fig. 4f) reached maximum abundance in the fall; cryptomonad abundance (Fig. 4d) peaked in the winter. *Rhodomonas minuta* (Fig. 4k) was the most abundant. *Dinobryon divergens*, *Cryptomonas* spp. (Fig. 4j), and *Ochromonas* spp. (Fig. 4ℓ) were also numerically important. Similar to the result described above for Port Huron, consistently lower abundances of these flagellates were observed in tap samples across all seasons.

RESULTS - STATISTICAL

Statistical analyses were conducted for each water treatment plant and season separately, since (1) no *a priori* reason existed for assuming that assemblage response to entrainment would be similar at different intake sites or at different seasons; (2) assemblage composition was not

similar enough across sites and seasons to allow merging of the data sets; and (3) the sampling design was not entirely consistent across sites or seasons.

The data were analyzed using both univariate paired-sample t-tests (parametric) and pairwise Wilcoxon rank sum tests (nonparametric). The two tests yielded similar results, but the pairwise Wilcoxon test was in general not as sensitive in detecting differences between the lake/tap groups. The paired-sample t-test depends on the assumptions of normality and homoscedasticity; the Wilcoxon test exhibits a slight power degradation typical of nonparametric techniques which reduce the actual scale of measurement to a gross relative measure. As the sample sizes used in this study were quite small (i.e. slight degradations in analytic power were not desirable) and since the t-test is robust to moderate deviations from the assumptions, the t-test was selected as the analysis of choice; only the t-test results are tabulated in the following sections.

PORT HURON - SUMMER

Table 2 summarizes the results of parallel univariate paired-sample t-tests, comparing lake and tap cell densities of selected taxa from Port Huron during the summer. Time series plots of the lake/tap cell density data used in the analyses are presented in Figs. 6a-ℓ. The composite *Rhodomonas* category (Fig. 6f) (which included *Rhodomonas minuta* and *R. minuta* var. *nannoplanctica*) and the divisions Chrysophyta (Fig. 6k) and Cryptophyta (Fig. 6ℓ) showed large, significant ($P>.95$) decreases in cell density after entrainment, even when the conservative Bonferroni test statistic was used. The undetermined flagellate category (Fig. 6a) also exhibited consistently lower cell densities at

TABLE 2. Port Huron--Summer. Summary of paired sample t-test results comparing lake and tap cell densities of selected taxa from a Port Huron summer phytoplankton assemblage. See Materials and Methods section for criteria used to select taxa for analysis. Starred values (*) are significant at α = .05 level using the Bonferroni critical value $t_{\alpha/p;N-1}$, where p = the number of simultaneous t-comparisons made on a single dataset. Sample size (N) = 12; p = 13, $t_{\alpha/p;N-1} = t_{.0038;11}$.

	Lake mean cell density (cells/L)	Tap mean cell density (cells/L)	Mean difference (lake-tap)	Std dev of difference	t-stat	Attained significance
<u>Individual taxa</u>						
Undetermined flagellates[1]	132.8	59.4	73.4	95.1	2.67	.0216
Cyclotella comensis	475.0	519.6	-44.6	155.7	-0.99	.3424
C. stelligera	15.3	12.1	3.2	9.6	1.17	.2664
Ochromonas spp.	15.5	11.1	4.4	28.8	0.52	.6117
Cryptomonas spp.	28.7	24.3	4.4	19.1	0.80	.4403
Rhodomonas minuta[2]	93.3	31.7	61.6	46.6	4.58	.0008*
<u>Composite categories</u>						
Total cells	1,446.9	1,133.8	313.1	670.3	1.62	.1340
Benthic	52.7	104.8	-52.1	100.2	-1.80	.0995
Undetermined[1]	132.8	59.4	73.4	95.1	2.67	.0216
Greens	117.5	86.5	31.0	149.2	0.72	.4870
Diatoms	629.4	724.7	-95.3	242.5	-1.36	.2009
Chrysophytes	238.9	66.1	172.8	89.9	6.66	.0000*
Cryptomonads	122.0	55.9	66.0	56.6	4.04	.0020*

[1]"Undetermined" composite category is synonymous with taxon designation "undetermined flagellates."
[2]This category included individuals identified as *Rhodomonas minuta* and as *R. minuta* var. *nannoplanctica*.

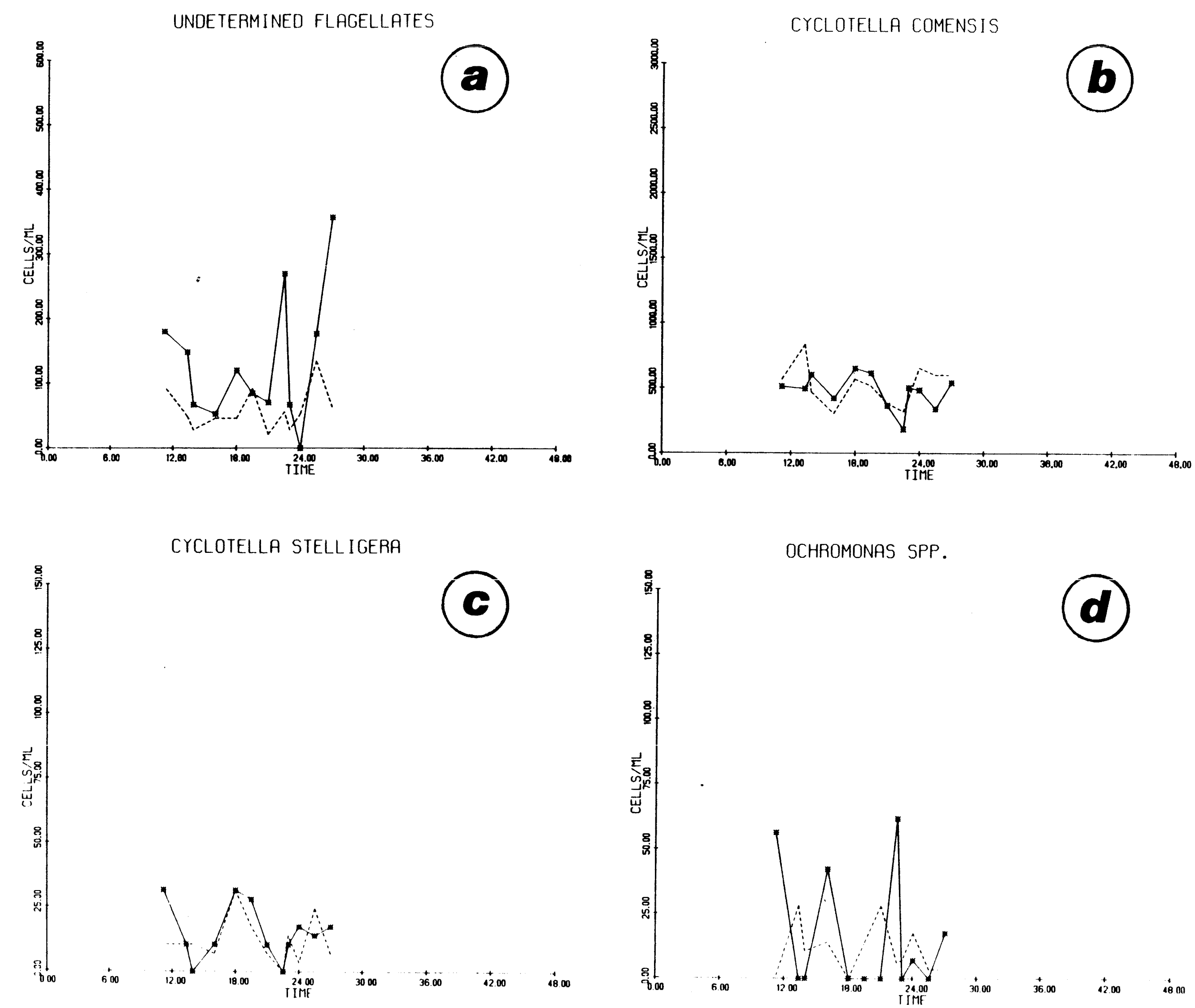
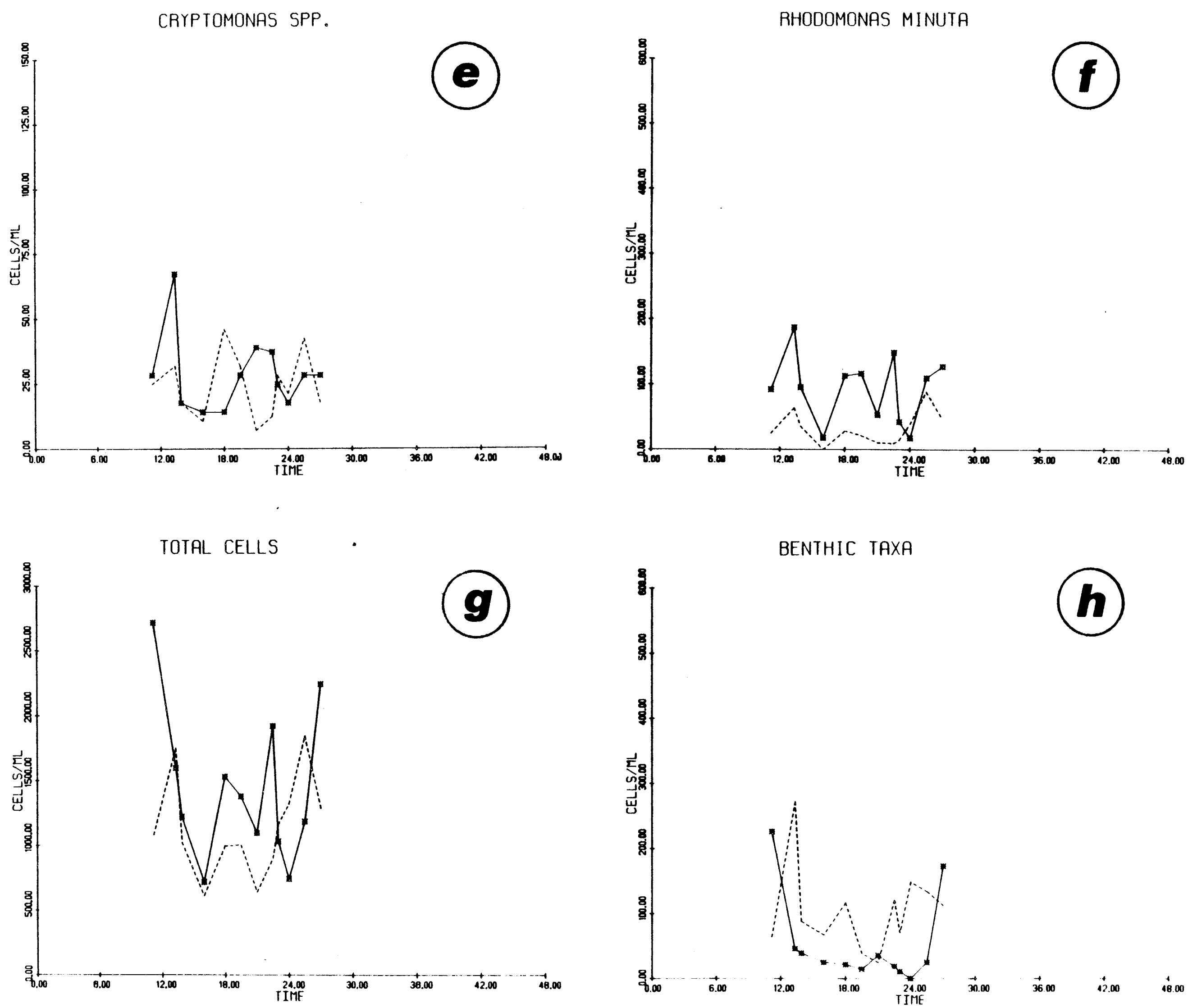


Fig. 6a-l. Port Huron - Summer. Cell densities (cells/mL) of selected taxa as a function of time during the 24-hr sampling period. Solid line = lake densities, dashed line = tap densities.



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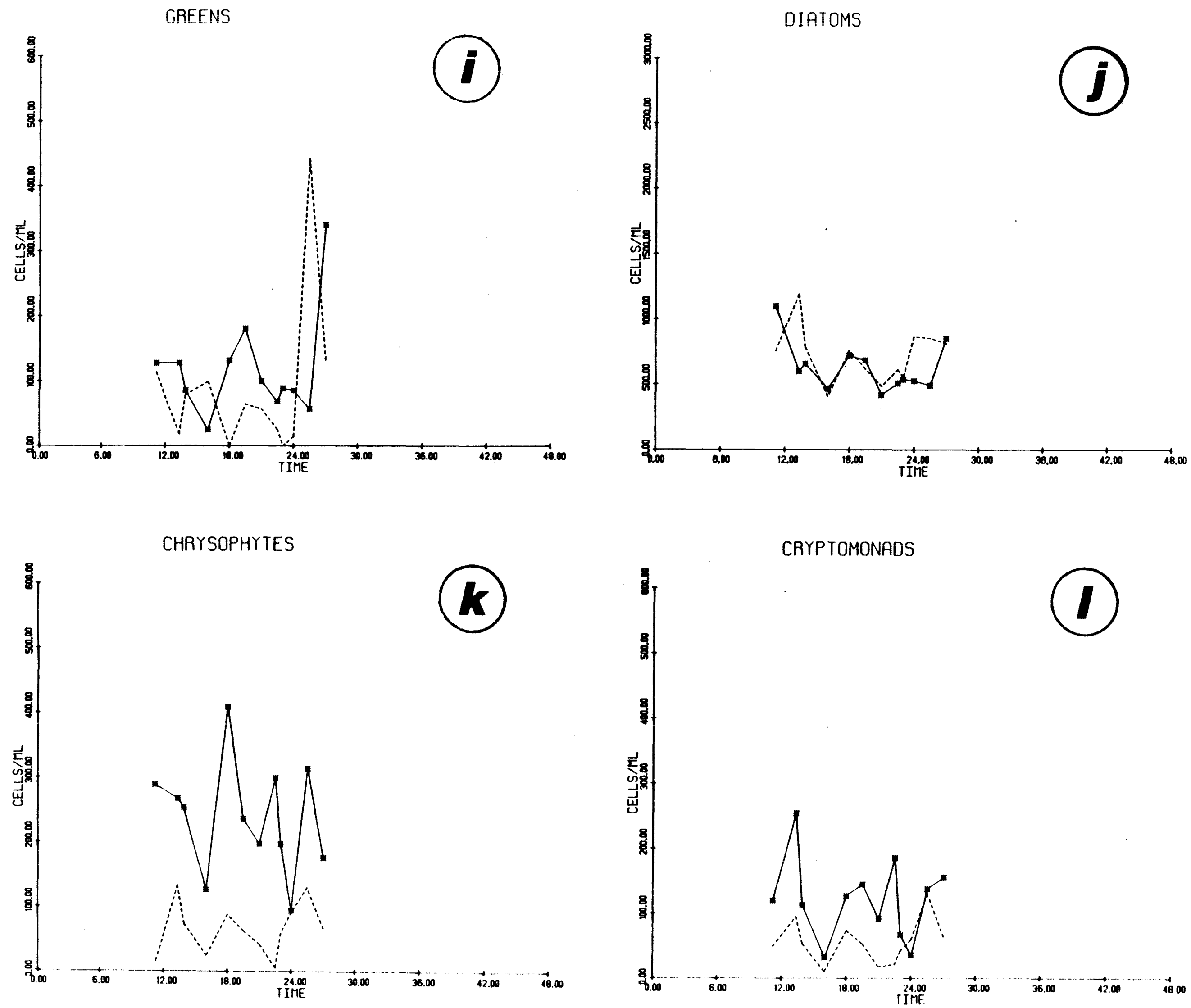


Fig. 6. (continued)

the tap, but the trend was not statistically significant using the Bonferroni critical value. *R. minuta* and total chrysophytes both decreased by approximately a factor of 3 after entrainment; undetermined flagellates and total cryptomonads decreased by more than a factor of 2. The benthic category (Fig. 6h) did not show quite such a consistent trend, but the preponderance of negative lake-tap differences warrants further testing for a potential increase in benthic cell densities due to entrainment. Many taxa exhibited large fluctuations in density that showed no apparent trend with time: undetermined flagellates increased from a low of zero to a high of 357 cells/mL within a 3-hr period; benthic taxa exhibited two maxima at the beginning and end of sampling (226 and 173 cells/mL respectively) and decreased to a low of zero between the two maxima.

A multivariate paired-sample Hotelling's T-square test comparing lake and tap samples using vectors of individual taxa cell densities (undetermined flagellates, *Cyclotella comensis*, *C. stelligera*, *Ochromonas* spp., *Cryptomonas* spp., and *Rhodomonas minuta*) showed no significant ($P<.95$) difference between lake and tap vectors. A comparable T-square test using vectors of composite category densities (total cells, benthic, undetermined, greens, diatoms, chrysophytes, cryptomonads) did show a significant difference between lake and tap vectors, but the small sample size did not permit further analysis to determine which composite categories were contributing to that difference.

Principal component analysis (PCA) was used to summarize graphically multivariate similarities among samples (Figs. 7a,b). The plot of the PCA of individual taxa densities (Fig. 7a) shows an apparent

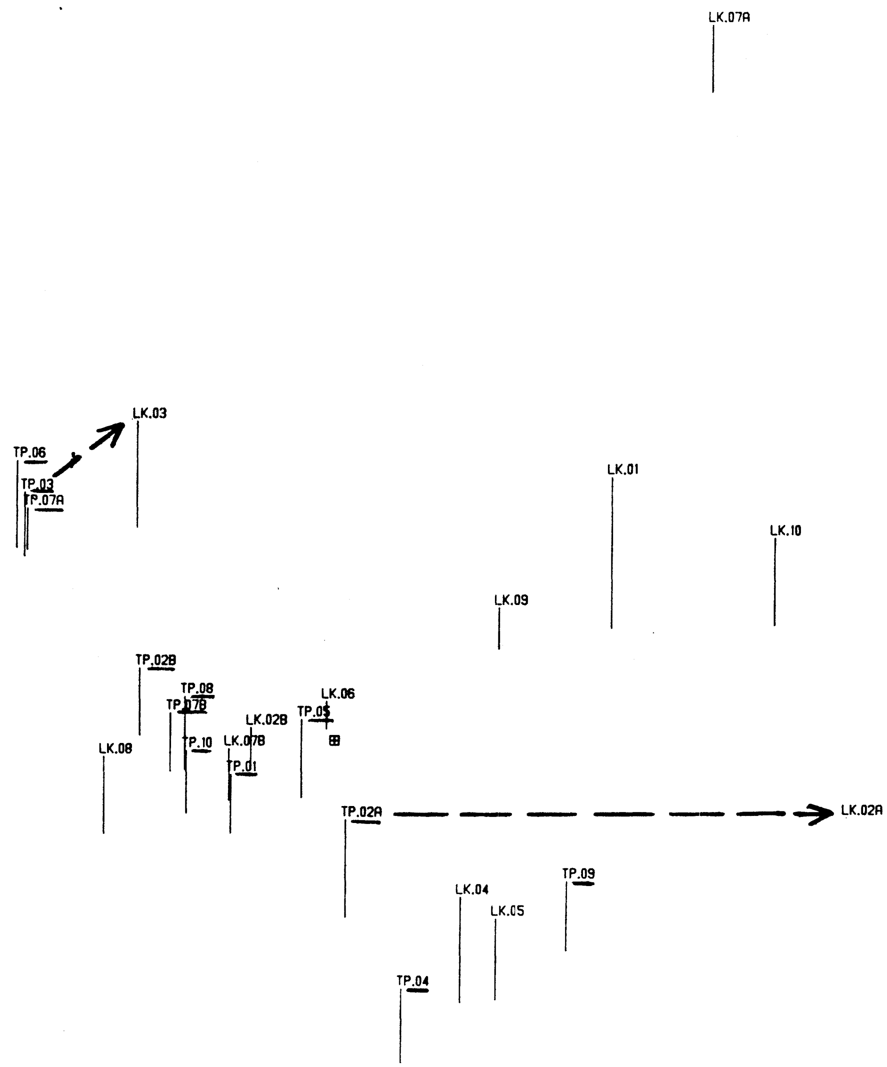


Fig. 7. Port Huron - Summer. Plot of lake and tap samples located according to their scores for the first (x-axis), second (y-axis), and third (z-axis) principal components. The principal component analysis (PCA) utilized the correlation matrix; variables were the taxa cell densities associated with a lake/tap sample. The x-y position of a given sample is located at the bottom end of the z-coordinate stick. The z-coordinate is represented as a positive distance up from the plane of the paper; the scale used to plot PC3 scores differs from that used for PC1 and PC2 scores. The cross designates the position of the origin. "Replicate" samples separated by 15 to 30 min are designated "A" and "B". (a) PCA of individual taxa cell densities, using the variables: undetermined flagellates, *Cyclotella comensis*, *C. stelligera*, *Ochromonas* spp., *Cryptomonas* spp., *Rhodomonas minuta*. Arrows connect lake/tap paired samples and are examples of a general translation along PC1 from a tap sample to its paired lake sample. (b) PCA of composite category cell densities, using the variables: total cells, benthic, undetermined, greens, diatoms, chrysophytes, and cryptomonads. The dashed line encloses a cluster of tap samples.

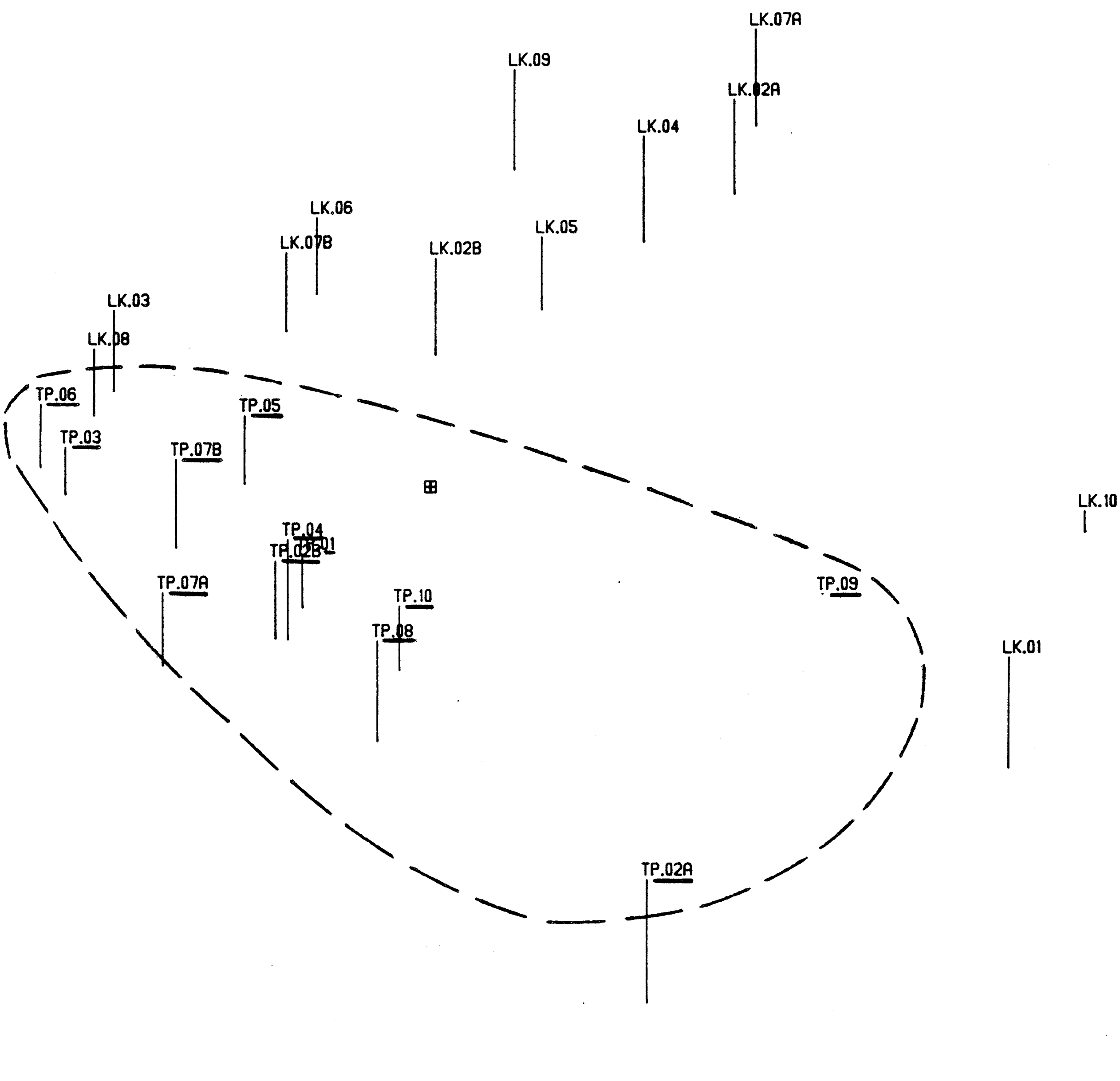


Fig. 7. (continued)

clustering of tap samples without showing a distinct lake/tap separation; in general, tap samples exhibit lower scores for the first principal component (PC1) than the corresponding lake samples (arrows - Fig. 7a). The largest loadings for PC1 (Table 3a) are associated with *Rhodomonas minuta* and undetermined flagellates, which implies that lake samples in general contained higher densities of these two taxa than did the corresponding tap samples. This is consistent with the raw data (Figs. 6a,f) and with results obtained above using the univariate t-test. The lack of separation into two distinct lake/tap clusters implies that the observed lake/tap differences occurred in general only between lake/tap paired samples. This suggests that variability of individual taxa densities due to lake/tap effects may be small compared to short- and long-range spatial heterogeneity in the lake.

The plot of the PCA of composite category densities (Fig. 7b) exhibits a similar clustering of tap samples, but in this case a very distinct lake/tap separation is shown. The magnitude of the PC2 score in general separates lake from tap samples. The largest loadings for PC2 are associated with chrysophytes and cryptomonads, the smallest with benthic taxa and diatoms (Table 3b). Lake samples contained consistently higher densities of chrysophytes and cryptomonads (Figs. 6k,ℓ); lake samples often contained lower densities of benthic and diatom taxa (Figs. 6h,j), but the trend is not as consistent. In particular, lake samples 1 and 10 exhibited exceptionally high total densities and correspondingly high benthic and diatom densities, which is reflected in their position at the lower right of Fig. 7b. Contrary to the result obtained above in the individual taxa PCA, the distinct

TABLE 3. Port Huron - Summer. Tables of taxa loadings associated with the first three principal components from PCAs using (a) selected individual taxa cell densities and (b) composite category cell densities. See Figures 7a,b for a more complete description of the PCAs.

TABLE 3a.

	PC1	PC2	PC3
Undetermined flagellates	.54845	.29751	.10124
Cyclotella comensis	.07092	-.61245	.30853
C. stelligera	.26266	-.45761	.54881
Ochromonas spp.	.10345	.54559	.64232
Cryptomonas spp.	.49551	-.16571	-.39806
Rhodomonas minuta	.60741	.04302	-.14943

TABLE 3b.

	PC1	PC2	PC3
Total density	.50625	-.11156	.09815
Benthic	.24994	-.61484	.08984
Undetermined	.43266	.20254	-.19546
Greens	.32163	.04671	-.82320
Diatoms	.30960	-.54076	.17923
Crysophytes	.33470	.41628	.45641
Cryptomonads	.42746	.31719	.16127

separation of lake and tap samples suggests that lake/tap differences in composite category densities may be *large* relative to short- and long-range spatial heterogeneity in the lake.

PORT HURON - SPRING

Table 4 summarizes the results of parallel univariate paired-sample t-tests, comparing lake and tap cell densities of selected taxa from Port Huron during the spring. Time series plots of the original lake/tap cell density data are presented in Figures 8a-n. Note that only six lake/tap sample pairs were obtained. *Cryptomonas* spp. (Fig. 8g), *Rhodomonas minuta* (Fig. 8h), and total cryptomonads (Fig. 8n) all showed a consistent decline in cell density after entrainment, each decreasing by more than a factor of two. Due to the small sample size, these trends were not found to be statistically significant using the Bonferroni critical value. Undetermined flagellate densities (Fig. 8a) exhibited large variability during the 24-hr sampling period, ranging from 575 to 7 cells/mL in the lake and from 607 to 14 cells/mL at the tap. Lake and tap samples both showed a similar pattern of decreasing flagellate density across time.

The sample size was too small to permit calculation of the multivariate Hotelling's T-square statistic. Principal component analyses of individual taxa and composite category cell densities are summarized in Figures 9a,b respectively. It should be noted that multivariate analyses in general provide more reliable summaries of trends when the number of cases is large compared to the number of variables analyzed. The plot of the PCA of individual taxa densities (Fig. 9a) shows no distinct clustering of lake and tap samples; however, in general higher scores for PC1 are associated with the lake sample of

TABLE 4. Port Huron--Spring. Summary of paired sample t-test results comparing lake and tap cell densities of selected taxa from a Port Huron spring phytoplankton assemblage. Starred values (*) are significant at $\alpha = .05$ level using the Bonferroni critical value $t_{\alpha/p;N-1}$. N = 6; p = 15; $t_{\alpha/p;N-1} = t_{.0033;5}$. See Materials and Methods section for more details of the analysis.

	Lake mean cell density (cells/mL)	Tap mean cell density (cells/mL)	Mean difference (lake-tap)	Std dev of difference	t-stat	Attained significance
Individual taxa						
Undetermined flagellates[1]	174.1	151.7	22.4	68.9	0.80	.4617
Cyclotella comensis	34.6	56.9	-22.3	62.5	-0.88	.4214
C. stelligera	15.8	25.7	- 9.9	16.8	-1.45	.2078
Synedra acus	19.4	16.4	3.0	14.2	0.51	.6294
S. filiformis	52.7	67.4	-14.7	29.6	-1.22	.2771
Dinobryon spp.	206.3	130.3	75.9	102.1	1.82	.1281
Cryptomonas spp.	26.4	11.7	14.7	11.0	3.26	.0224
Rhodomonas minuta[2]	74.5	23.4	51.1	45.5	2.76	.0401
Composite categories						
Total cells	1,935.7	1,930.0	5.7	632.0	0.02	.9832
Benthic	97.8	122.6	-24.8	116.8	-0.52	.6246
Undetermined[1]	174.1	151.7	22.4	68.9	0.80	.4617
Greens	59.6	133.3	-73.7	93.0	-1.94	.1100
Diatoms	1,311.3	1,389.7	-78.4	518.3	-0.37	.7261
Chrysophytes	222.1	142.0	80.1	107.1	1.83	.1266
Cryptomonads	101.0	35.1	65.9	52.5	3.07	.0277

[1]"Undetermined" composite category is synonymous with taxon designation "undetermined flagellates."
[2]This category included individuals identified as *Rhodomonas minuta* and as *R. minuta* var. *nannoplanctica*.

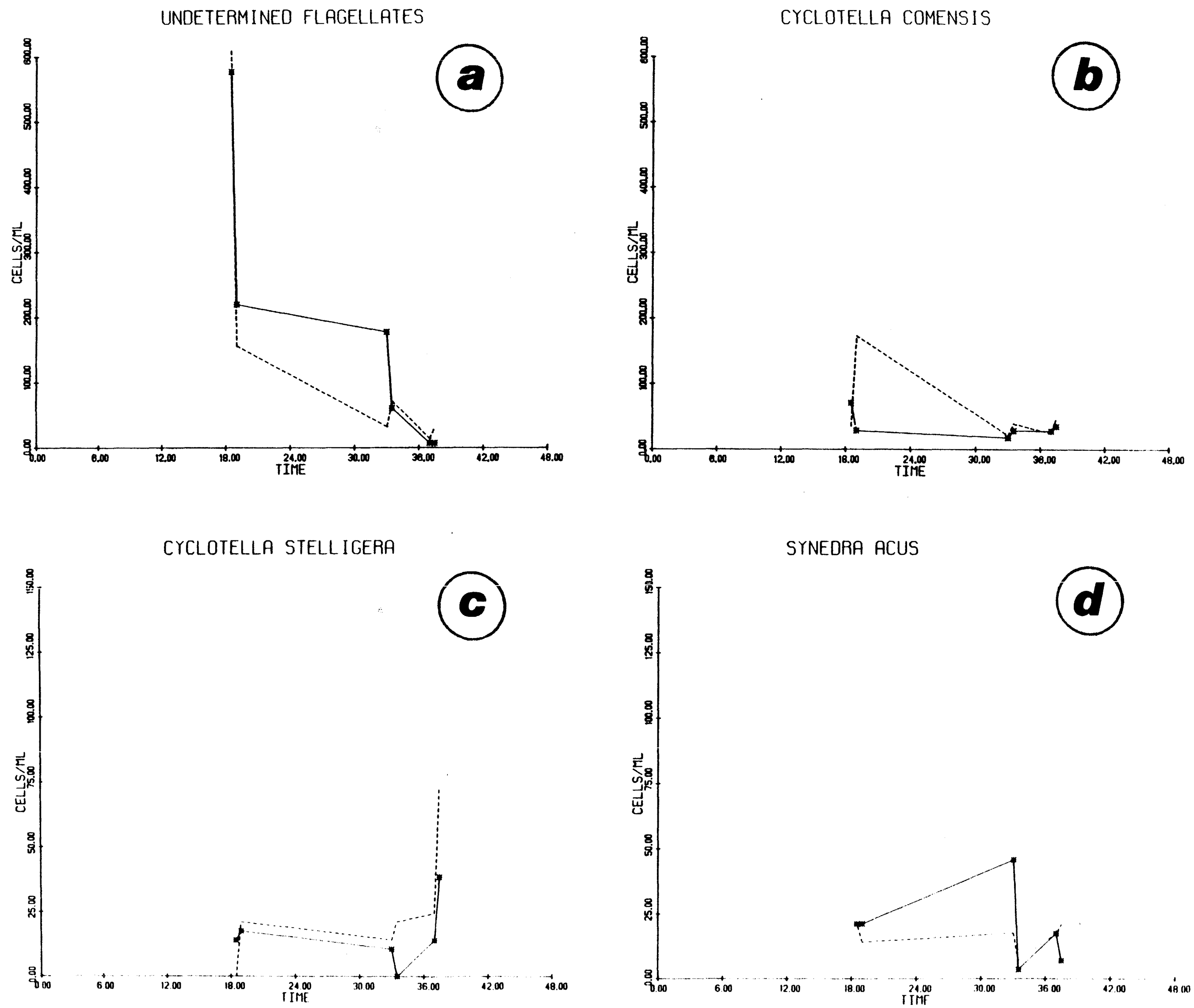


Fig. 8a-n. Port Huron - Spring. Cell densities (cells/mL) of selected taxa as a function of time during the 24-hr sampling period. Solid line = lake densities, dashed line = tap densities.

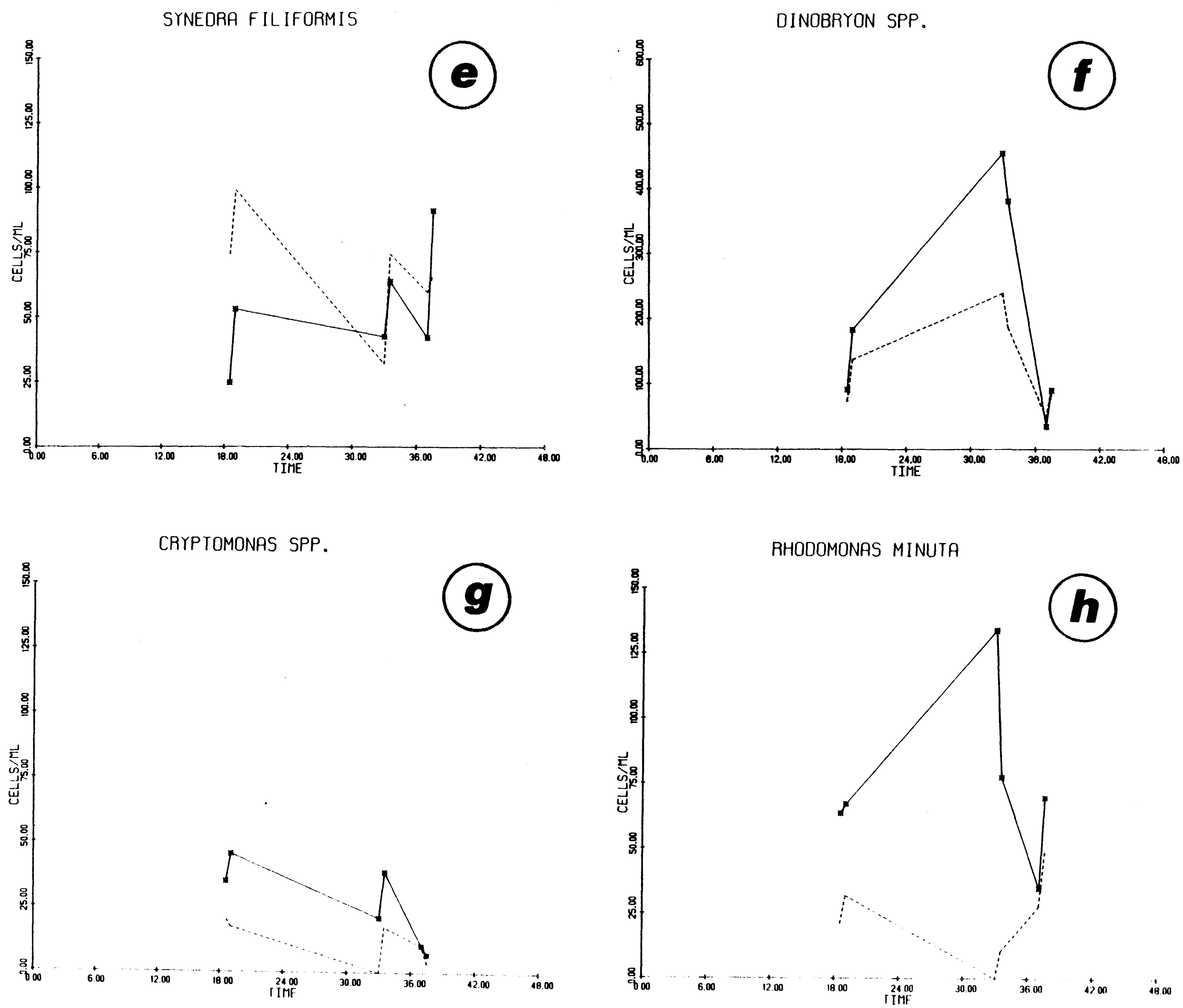
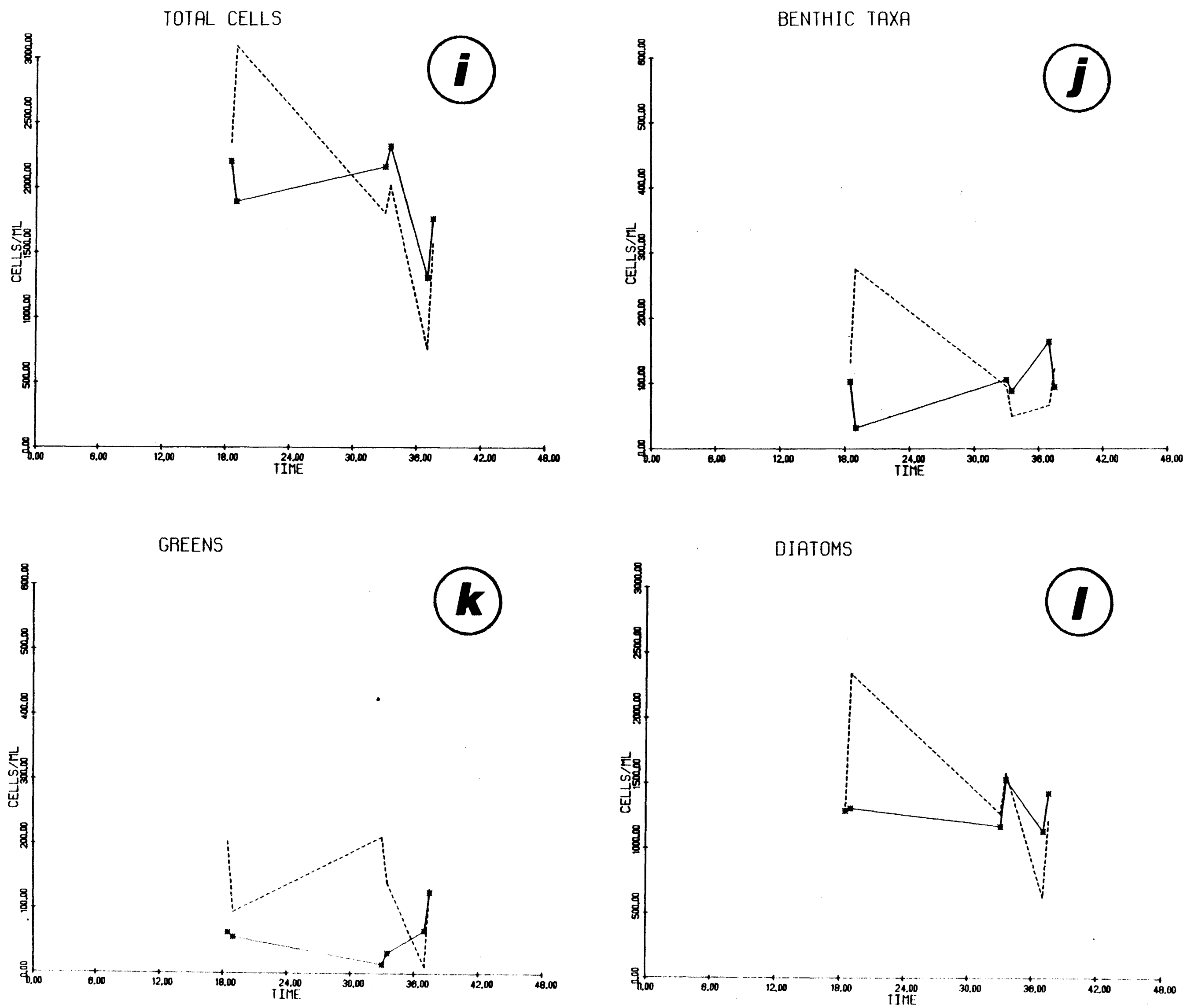


Fig. 8. (continued)



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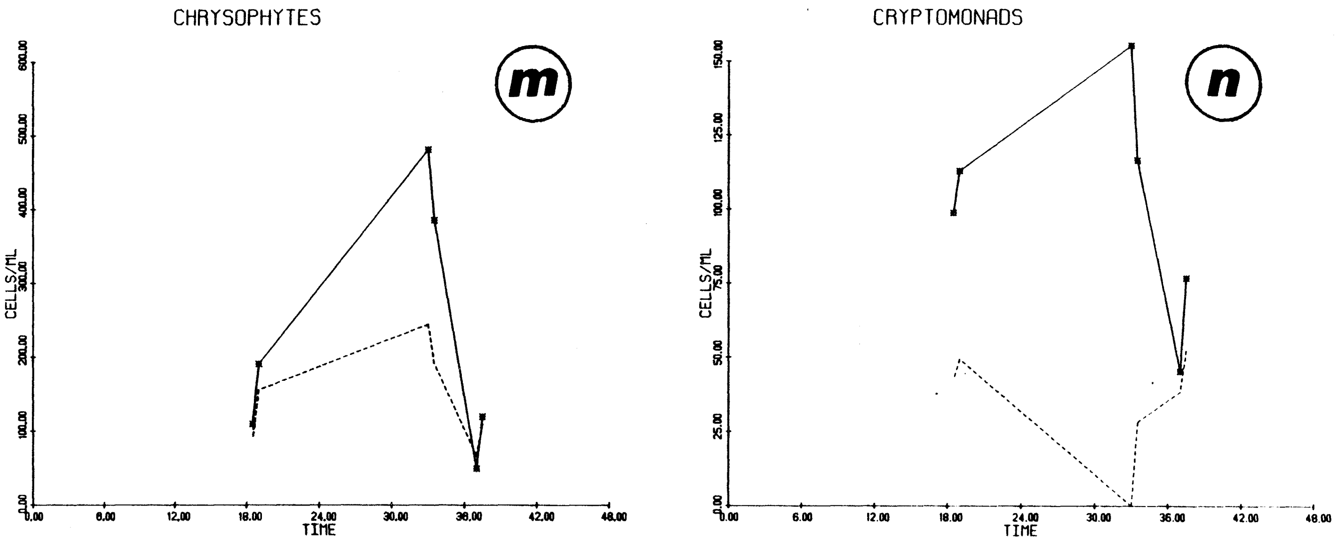

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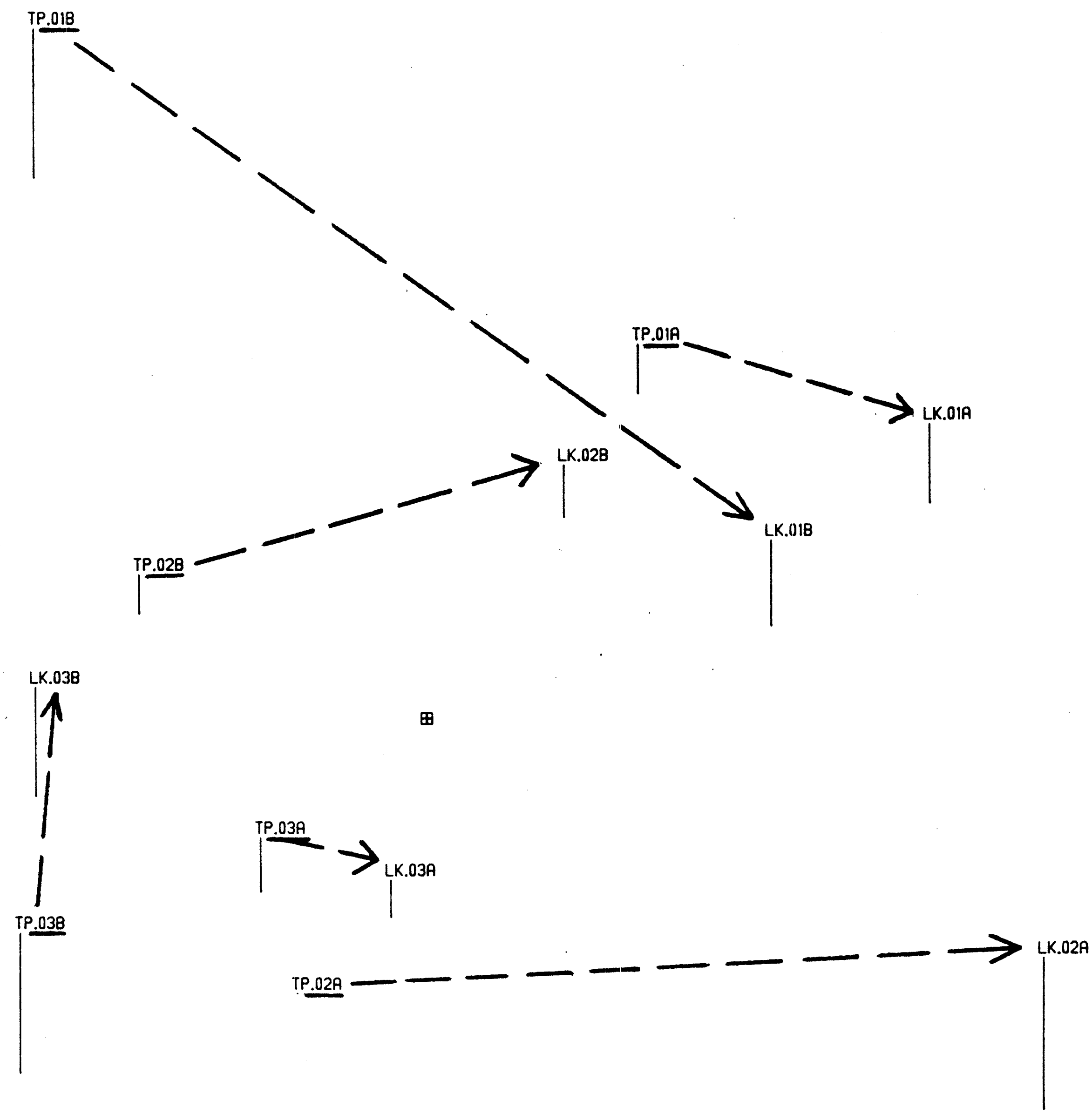


Fig. 9. Port Huron - Spring. Plot of lake and tap samples located according to their scores for the first (x-axis), second (y-axis), and third (z-axis) principal components. The x-y position of a given sample is located at the bottom end of the z-coordinate stick. The cross designates the position of the origin. See caption of Fig. 7 for more details of the analysis and plotting technique. (a) PCA of individual taxa cell densities: using the variables undetermined flagellates, *Cyclotella comensis, C. stelligera, Synedra acus, S. filiformis, Cryptomonas* spp., *Rhodomonas minuta.* Arrows connect lake/tap paired samples and illustrate a general translation along PC1 from a tap sample to its paired lake sample. (b) PCA of composite category cell densities: using the variables total density, benthic, undetermined, greens, diatoms, chrysophytes, cryptomonads. The dashed lines encircle "replicate" samples taken approximately 15 min apart.

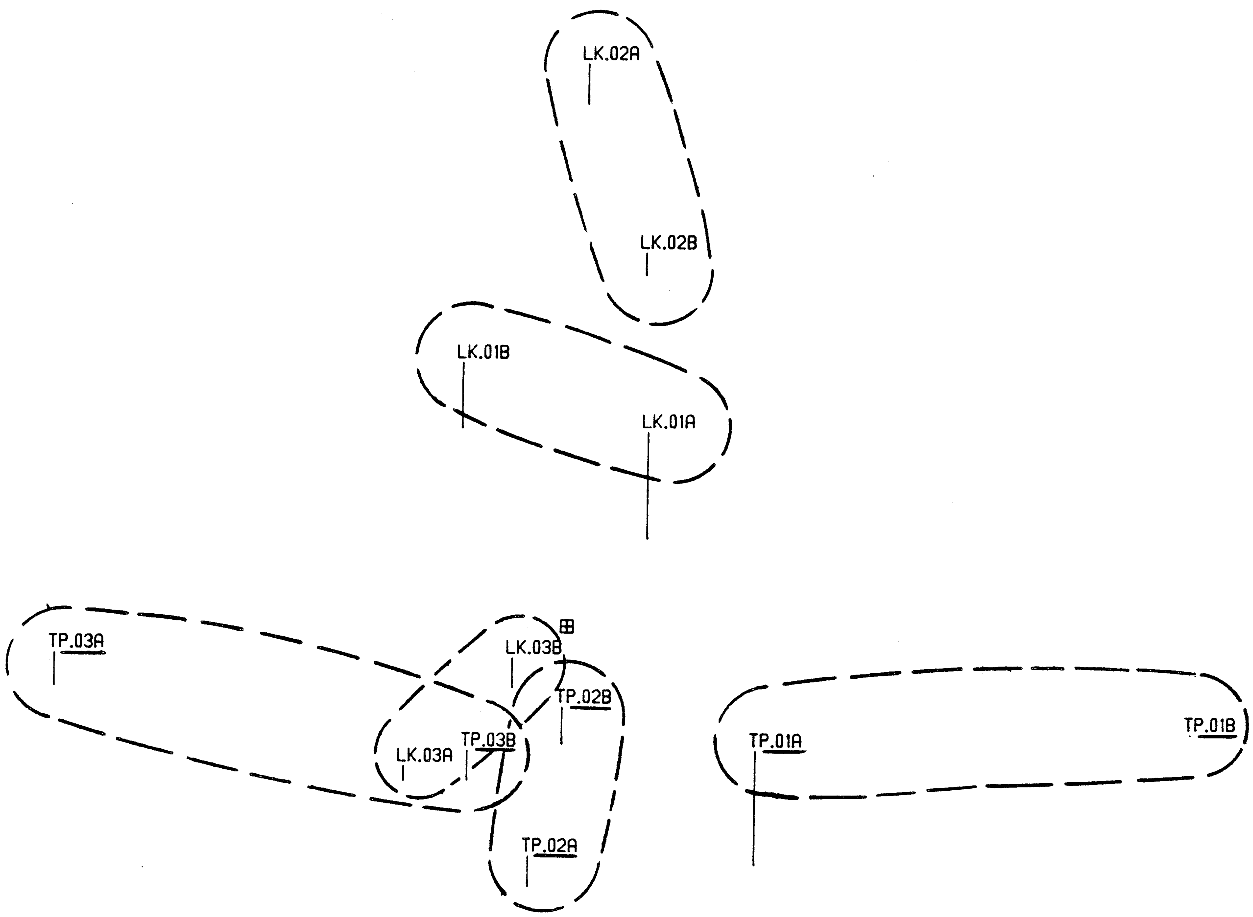


Fig. 9. (continued)

a lake/tap pair (arrows - Fig. 9a). This effect is probably due to the taxa *R. minuta* and *Cryptomonas* spp., which have high positive loadings for PC1 (Table 5a) and show consistently higher densities in the lake samples.

The plot of the PCA of composite category densities (Fig. 9b) exhibits an unusual separation of lake/tap samples, with tap samples dispersed along PC1 and lake samples along PC2. This suggests that different sources are contributing to the major variability found within each group. All loadings are positive for PC1: the largest values are associated with total density, diatoms, and benthic taxa. Figures 8i,j,ℓ indicate the existence of wide variability across time in the tap samples for each of these composite groups, with the highest densities in general associated with tap sample 1B and the lowest with tap sample 3A, which are the most widely separated samples on PC1. Large positive loadings for PC2 (Table 5b) are associated with cryptomonads and chrysophytes. Tap samples, which have low scores for PC2, in general contained lower densities of chrysophytes and cryptomonads. Note that the "replicate" samples tend to cluster more tightly than other time points. PC3 has a very large positive loading associated with the undetermined flagellate category; lake sample 1A and tap sample 1A are separated from the others on the basis of this characteristic.

ALPENA - SUMMER

Time series plots of lake/tap cell densities of selected taxa from Alpena summer samples are presented in Figures 10a-p. Parallel univariate paired-sample t-tests comparing lake and tap cell densities found no significant differences for any of the taxa examined, using the Bonferroni critical value (Table 6). However, several taxa exhibited

TABLE 5. Port Huron - Spring. Tables of taxa loadings associated with the first three principal components from PCAs using (a) selected individual taxa cell densities and (b) composite category cell densities. See Figures 9a,b for a more complete description of the PCAs.

TABLE 5a.

	PC1	PC2	PC3
Undetermined flagellates	.38989	.40851	.01307
Cyclotella comensis	-.20399	.52311	.43941
C. stelligera	-.38499	-.32879	.43748
Synedra acus	.40048	-.34326	.39034
S. filiformis	-.41105	.36465	.35054
Cryptomonas spp.	.43216	.40917	.05032
Rhodomonas minuta	.37690	-.18206	.58102

TABLE 5b.

	PC1	PC2	PC3
Total density	.60776	.13883	.10315
Benthic	.44138	-.17177	-.31741
Undetermined	.23476	.02738	.85533
Greens	.17551	-.50502	.20101
Diatoms	.57863	-.02671	-.25054
Crysophytes	.11483	.53254	-.17653
Cryptomonads	.04360	.64118	.15061

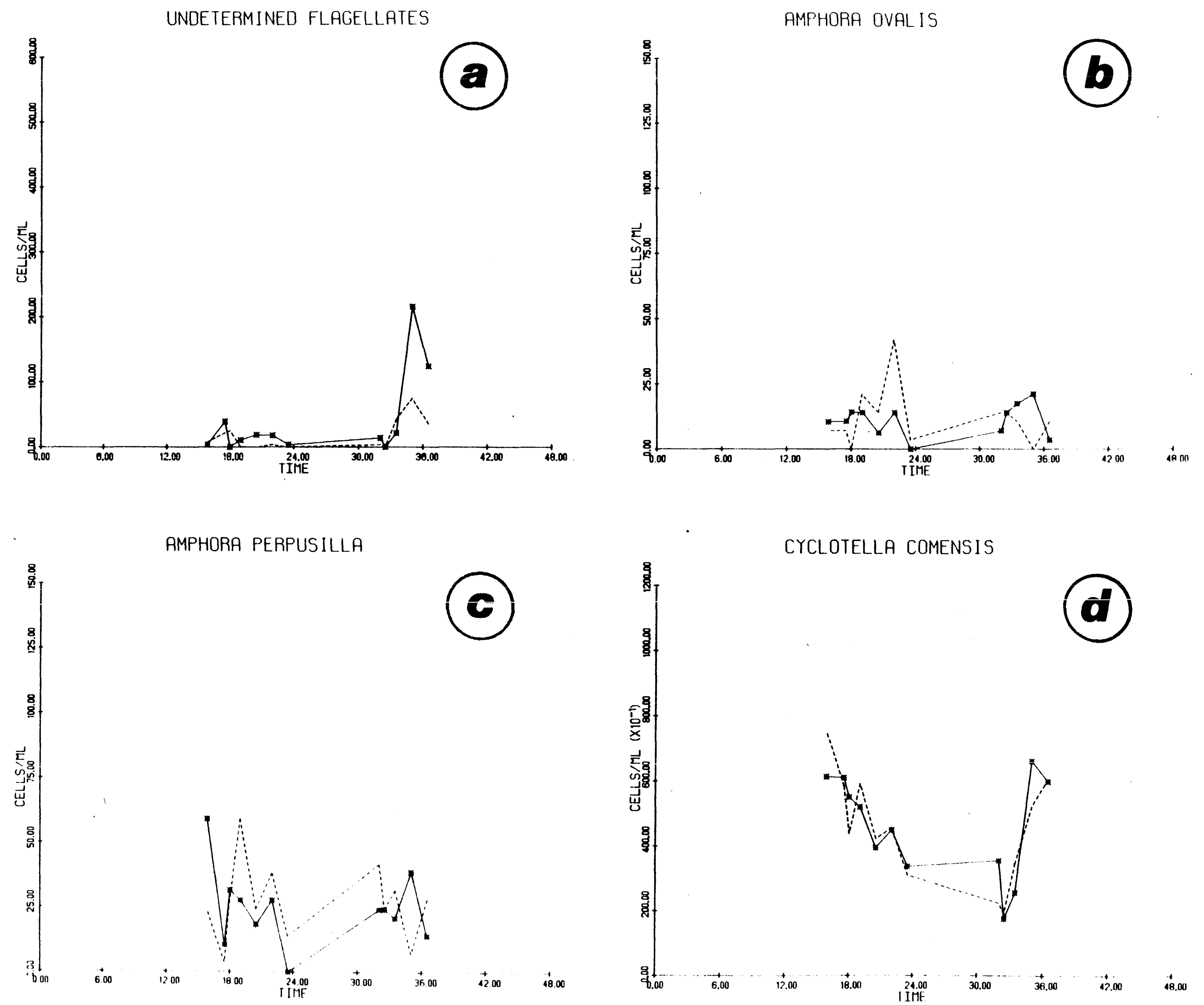


Fig. 10a-p. Alpena - Summer. Cell densities (cells/mL) of selected taxa as a function of time during the 24-hr sampling period. Solid line = lake densities, dashed line = tap densities.

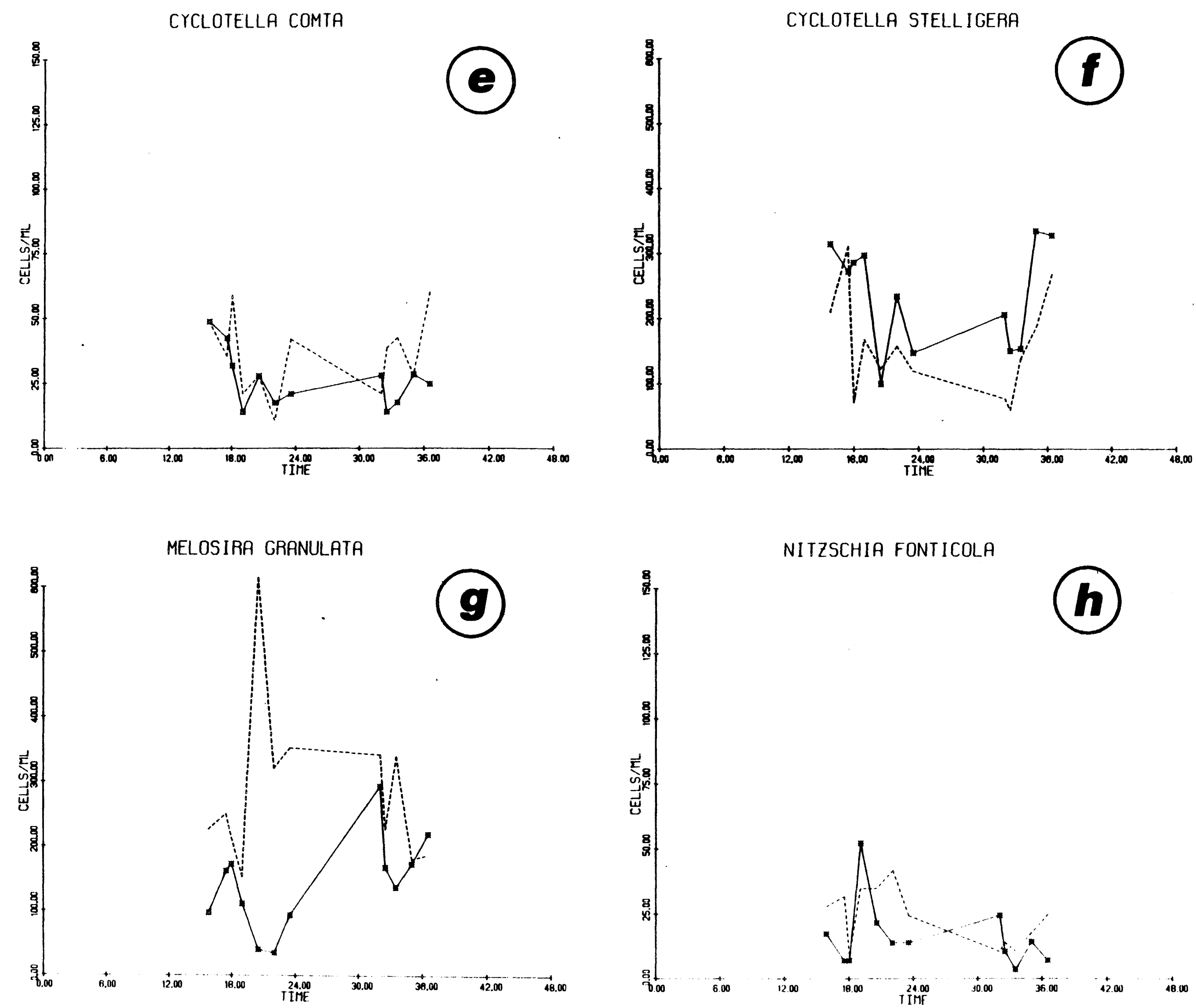


Fig. 10. (continued)

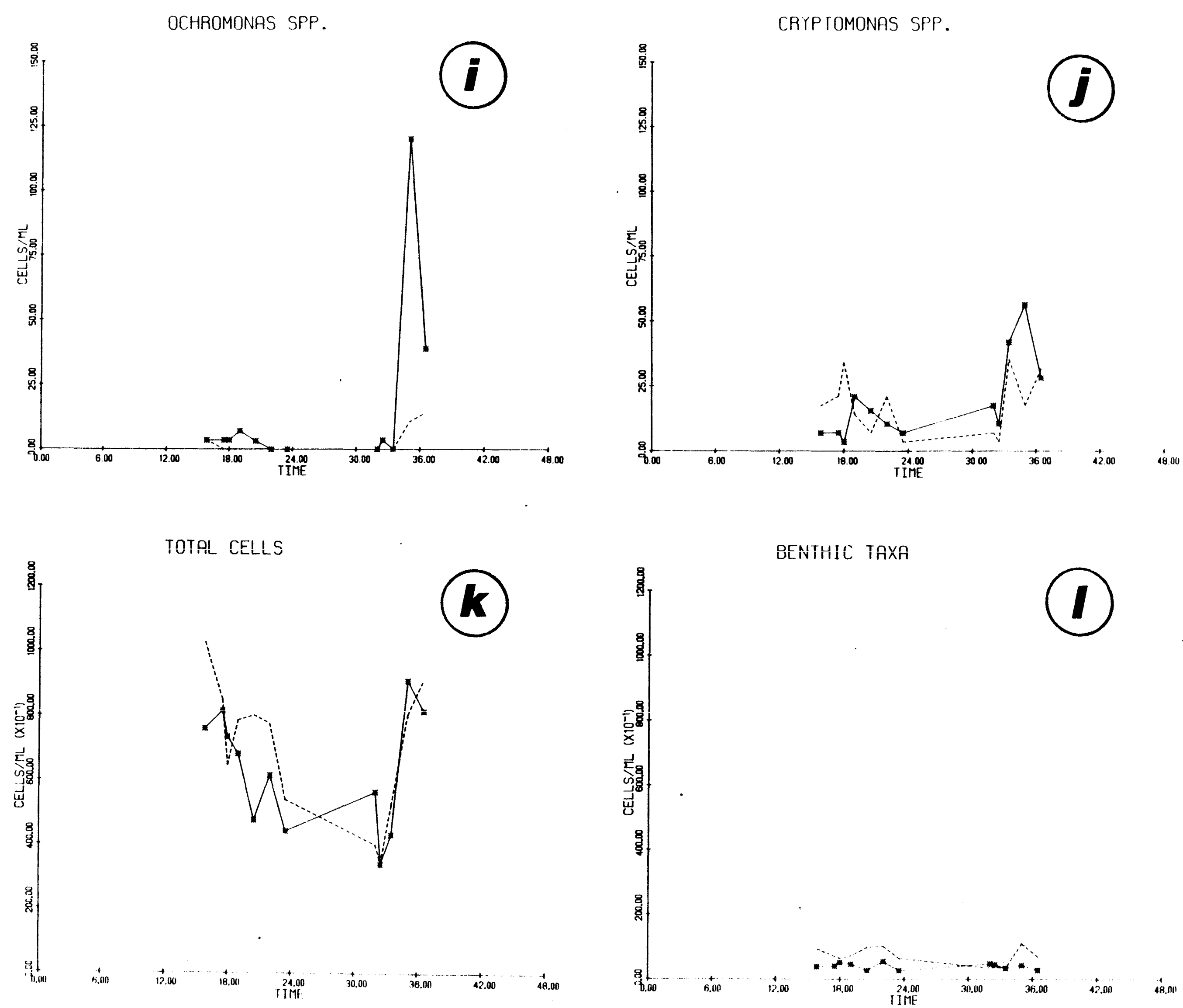


Fig. 10. (continued)

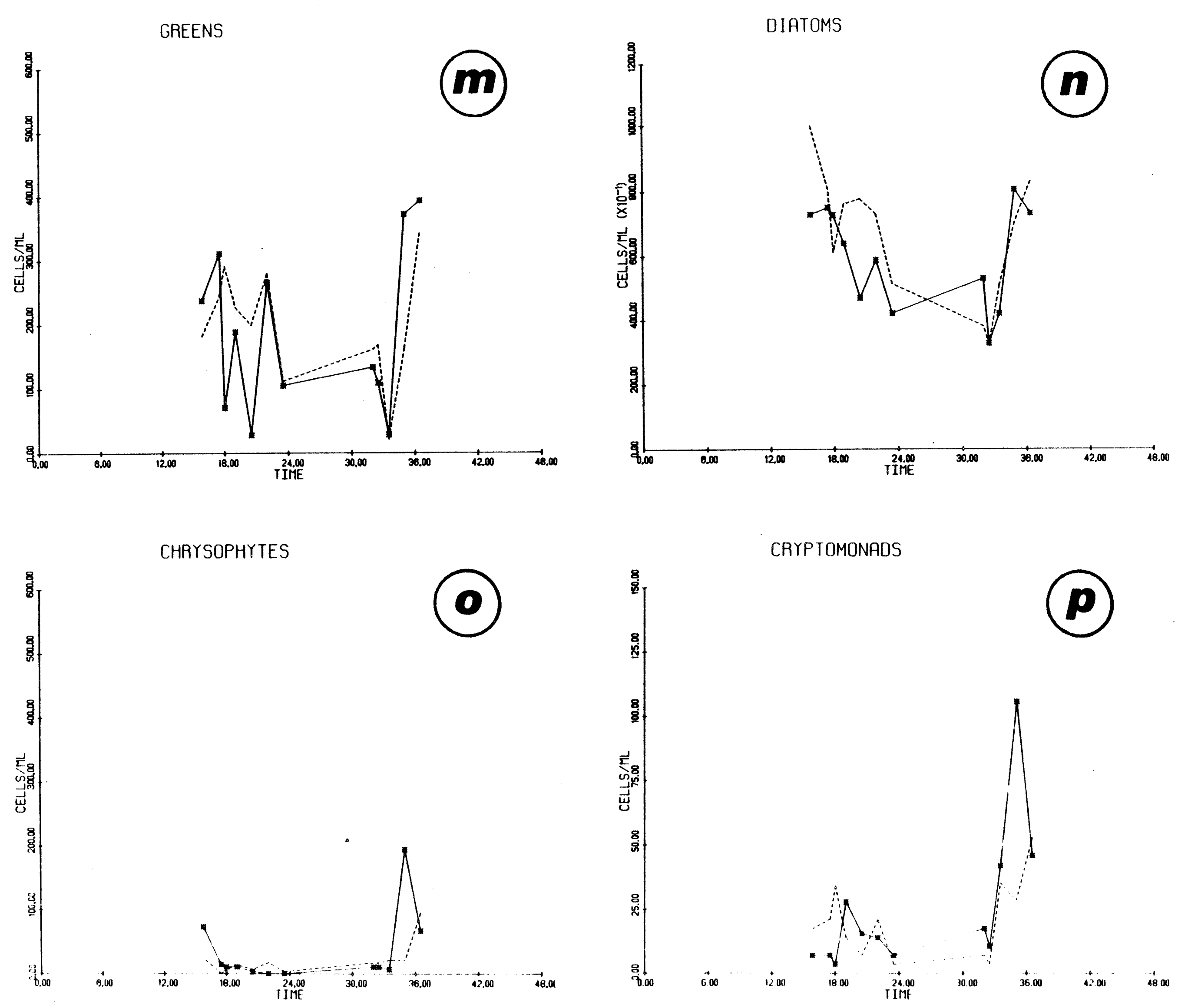


Fig. 10. (continued)

TABLE 6. Alpena--Summer. Summary of paired sample t-test results comparing lake and tap cell densities of selected taxa from an Alpena summer phytoplankton assemblage. Starred values (*) are significant at α = .05 level using the Bonferroni critical value $t_{\alpha/p;N-1}$. N = 12; p = 17; $t_{\alpha/p;N-1} = t_{.0029;11}$. See Materials and Methods section for more details of the analysis.

	Lake mean cell density (cells/mL)	Tap mean cell density (cells/mL)	Mean difference (lake-tap)	Std dev of difference	t-stat	Attained significance
Individual taxa						
Undetermined flagellates[1]	38.8	17.6	21.2	47.2	1.56	.1480
Amphora ovalis	11.0	11.9	-0.9	12.5	-0.26	.8031
A. perpusilla	24.9	27.1	-2.2	19.5	-0.39	.7027
Cyclotella comensis	4,601.2	4,537.0	64.2	880.6	0.25	.8055
C. comta	26.3	36.2	-9.9	15.5	-2.20	.0497
C. stelligera	235.1	157.2	77.9	74.0	3.65	.0038
Melosira granulata	141.9	284.0	-142.1	168.4	-2.92	.0139
Nitzschia fonticola	16.1	23.5	-7.4	13.5	-1.91	.0827
Ochromonas spp.	15.2	2.6	12.6	31.3	1.40	.1902
Cryptomonas spp.	18.8	17.8	1.0	17.0	0.22	.8332
Composite categories						
Total cells	6,325.1	7,018.6	-693.5	1,450.2	-1.66	.1258
Benthic	395.2	704.0	-308.8	284.3	-3.76	.0031
Undetermined[1]	38.8	17.6	21.2	47.2	1.56	.1480
Greens	186.3	199.2	-12.9	110.8	-0.40	.6954
Diatoms	5,944.7	6,628.2	-683.5	1,434.6	-1.65	.1271
Chrysophytes	33.4	20.4	13.0	53.9	0.83	.4222
Cryptomonads	25.3	20.4	4.9	26.2	0.64	.5328

[1]"Undetermined" composite category is synonymous with taxon designation "undetermined flagellates."

consistent trends that may warrant further examination. *M. granulata* (Fig. 10g) increased from a mean density of 142 cells/mL in the lake to 284 cells/mL at the tap; benthic taxa (Fig. 10ℓ) showed a similar increase after entrainment: a mean of 395 cells/mL in the lake compared to 704 cells/mL at the tap.

A multivariate paired-sample Hotelling's T-square test comparing lake and tap samples using vectors of individual taxa cell densities (undetermined flagellates, *Amphora ovalis*, *A. perpusilla*, *Cyclotella comensis*, *C. comta*, *C. stelligera*, *Nitzschia fonticola*, *Ochromonas* spp., and *Cryptomonas* spp.) found a significant (P>.99) difference between lake and tap vectors. The sample size was too small to determine which taxa were the major contributors to that observed difference. A comparable multivariate test comparing vectors of composite category densities (benthic, undetermined, greens, diatoms, chrysophytes, and cryptomonads) found no significant difference between the lake and tap vectors.

The plot of the PCA of individual taxa densities (Fig. 11a) shows no indication of a lake/tap clustering. In general lake/tap paired samples and adjacent time points tend to cluster (arrows - Fig. 11a). PC1 separates lake samples 9 and 10 from the remaining samples. Taxa with the largest loadings (all positive) for PC1 (Table 7a) are undetermined flagellates, *Ochromonas* spp., *Cryptomonas* spp., and *Cyclotella stelligera*. Lake samples 9 and 10 both contain unusually high densities of each of these taxa (Figs. 10a,f,i,j).

The plot of the PCA of composite categories (Fig. 11b) shows a systematic difference between lake and tap samples for PC2. In general tap samples have a lower PC2 score than the corresponding lake samples

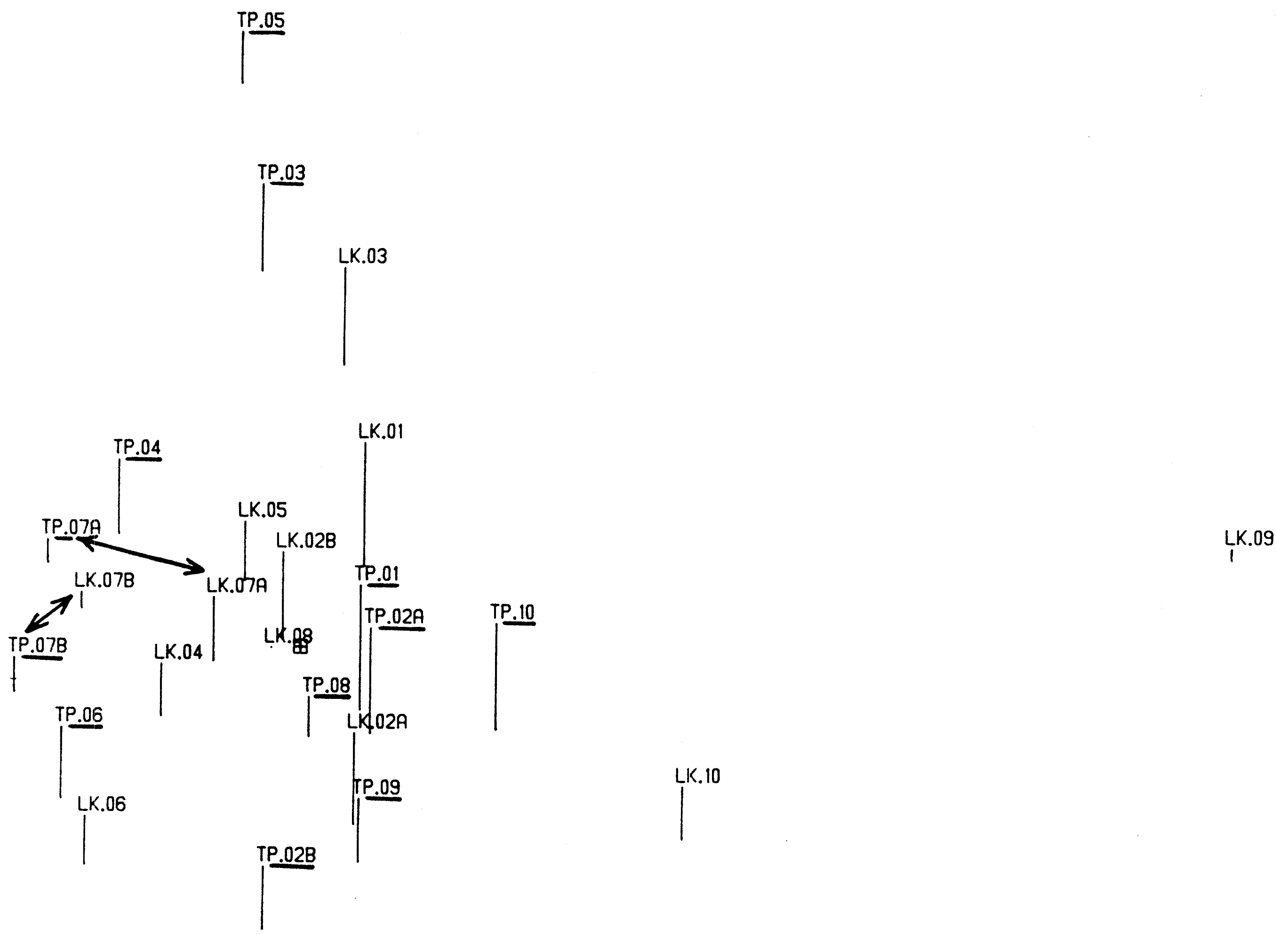


Fig. 11. Alpena - Summer. Plot of lake and tap samples located according to their scores for the first (x-axis), second (y-axis), and third (z-axis) principal components. The x-y position of a given sample is located at the bottom end of the z-coordinate stick. The cross designates the position of the origin. See caption of Figure 7 for more details of the analysis and plotting technique. (a) PCA of individual taxa cell densities: using the variables undetermined flagellates, *Amphora ovalis, A. perpusilla, Cyclotella comensis, C. comta, C. stelligera, Nitzschia fonticola, Ochromonas* spp., *Cryptomonas* spp. Arrows connect lake/tap paired samples and illustrate a general clustering both of lake/tap paired samples and of adjacent time points. (b) PCA of composite category cell densities: using the variables benthic, undetermined, greens, diatoms, chrysophytes, cryptomonads. Arrows connect lake/tap paired samples and are examples of a general translation along PC2 from a lake sample to its paired tap sample.

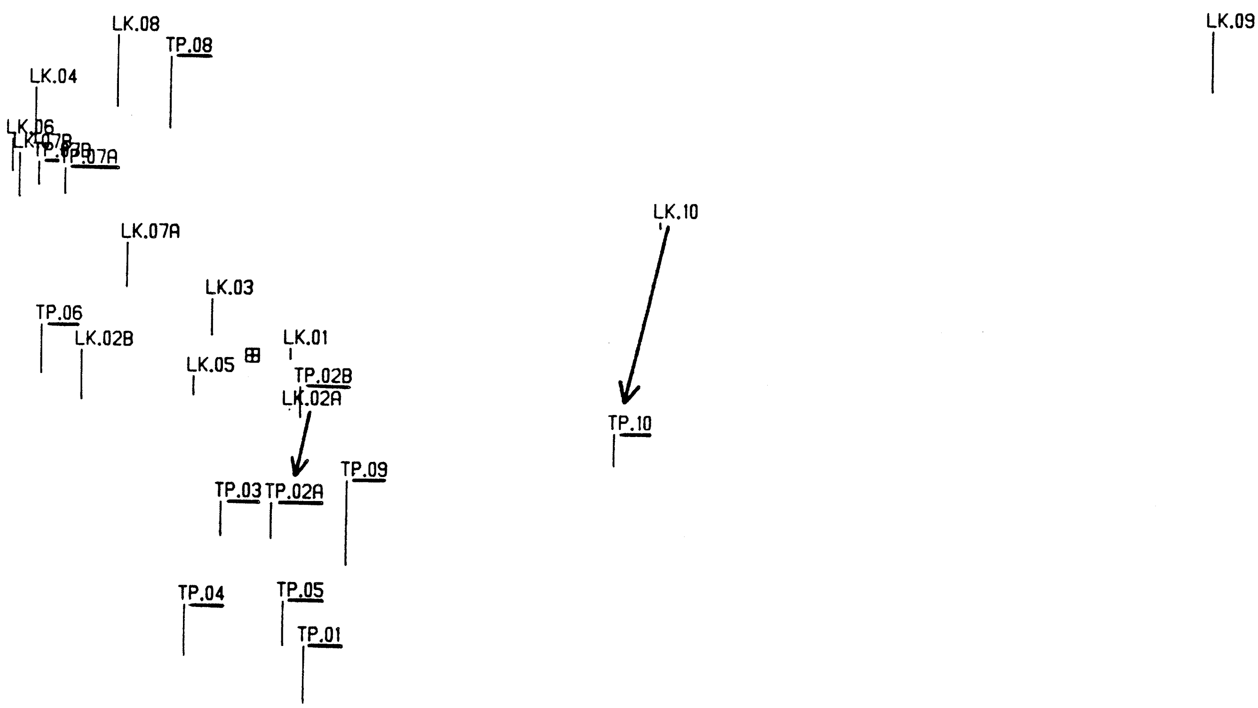


Fig. 11. (continued)

TABLE 7. Alpena - Summer. Tables of taxa loadings associated with the first three principal components from PCAs using (a) selected individual taxa cell densities and (b) composite category cell densities. See Figures 11a,b for a more complete description of the PCAs.

TABLE 7a.

	PC1	PC2	PC3
Undetermined flagellates	.51200	-.12037	-.25097
Amphora ovalis	.05815	.63945	-.17513
A. perpusilla	.07025	.47025	.06350
Cyclotella comensis	.37254	.04347	.56768
C. comta	.07071	-.39347	.41302
C. stelligera	.40079	.04976	.35679
Nitzschia fonticola	-.04345	.44269	.38931
Ochromonas spp.	.50199	.01392	-.24203
Cryptomonas spp.	.41381	-.01126	-.26838

TABLE 7b.

	PC1	PC2	PC3
Benthic	.06264	-.70404	.47624
Undetermined	.48842	.24832	.19392
Greens	.41226	-.23757	-.76005
Diatoms	.32832	-.54865	-.02679
Crysophytes	.49715	.18506	.01302
Cryptomonads	.48230	.22576	.39626

in each lake/tap pair (arrows - Fig. 11b); however, the samples do not separate into distinct lake/tap clusters. The benthic category has a very large (in absolute value) negative loading for PC2, i.e. benthic densities tend to be higher in tap samples (Fig. 10ℓ). PC1 separates lake samples 9 and 10 and tap sample 10 from the remaining samples, similar to results from the PCA of individual taxa. Groups with large loadings (all positive) for PC1 in this analysis (Table 7b) include chrysophytes (Fig. 10o), undetermined flagellates (Fig. 10a), and cryptomonads (Fig. 10p), which all exhibit unusually high densities in lake samples 9 and 10 and tap sample 10.

ALPENA - FALL

Univariate paired-sample t-tests found no significant difference between lake and tap samples from Alpena during the fall for any of the taxa examined (Table 8). Time series plots of the original lake/tap cell densities (Figs. 12a-p) show no consistent lake/tap trends.

A multivariate Hotelling's T-square test comparing (1) vectors of individual taxa cell densities (undetermined flagellates, *Amphora perpusilla*, *Cyclotella comensis*, *C. comta*, *C. stelligera*, *Nitzschia acicularis*, *N. gracilis*, *Ochromonas* spp., *Rhodomonas minuta*) and (2) vectors of composite category densities (total cells, benthic, undetermined, greens, diatoms, chrysophytes, cryptomonads) found no significant differences between the lake and tap vectors.

The plots of the PCAs of individual taxa densities (Fig. 13a) and of composite category densities (Fig. 13b) show no indication of a lake/tap clustering, but do show a separation across time. PC1 in both cases separates lake samples 8, 9, and 10 and tap samples 7B, 8, 9 and 10 from the remaining samples. *Cyclotella comensis* (Fig. 12c),

TABLE 8. Alpena--Fall. Summary of paired sample t-test results comparing lake and tap cell densities of selected taxa from an Alpena fall phytoplankton assemblage. Starred values (*) are significant at $\alpha = .05$ level using the Bonferroni critical value $t_{\alpha/p;N-1}$. $N = 12$, $p = 17$; $t_{\alpha/p;N-1} = t_{.0029;11}$. See Materials and Methods section for more details of the analysis.

	Lake mean cell density (cells/mL)	Tap mean cell density (cells/mL)	Mean difference (lake-tap)	Std dev of difference	t-stat	Attained significance
Individual taxa						
Undetermined flag-ellates[1]	74.7	57.2	17.5	63.6	0.95	.3614
Amphora perpusilla	22.6	33.8	-11.2	24.5	-1.59	.1412
Cyclotella comensis	1,263.1	1,513.7	-250.6	627.8	-1.38	.1940
C. comta	17.8	15.6	2.2	9.7	0.80	.4386
C. stelligera	25.6	35.6	-10.0	28.8	-1.20	.2563
Melosira granulata	124.1	136.7	-12.6	107.2	-0.41	.6921
Nitzschia acicularis	11.3	29.3	-18.0	23.4	-2.66	.0223
N. gracilis	6.7	10.8	-4.1	13.3	-1.07	.3084
Ochromonas spp.	17.9	9.9	8.0	17.6	1.57	.1450
Rhodomonas minuta[2]	36.9	30.7	6.2	31.2	0.68	.5088
Composite categories						
Total cells	4,846.1	4,619.3	226.8	1,984.9	0.40	.6998
Benthic	536.1	619.8	-83.7	197.3	-1.47	.1694
Undetermined[1]	74.7	57.2	17.5	63.6	0.95	.3614
Greens	160.6	177.6	-17.0	132.7	-0.44	.6653
Diatoms	2,528.8	3,012.2	-483.4	975.9	-1.72	.1141
Chrysophytes	230.4	115.5	114.9	232.2	1.71	.1146
Cryptomonads	49.1	40.3	8.8	37.8	0.81	.4348

[1]"Undetermined" composite category is synonymous with taxon designation "undetermined flagellates."
[2]This category included individuals identified as *Rhodomonas minuta* and as *R. minuta* var. *nannoplanctica*.

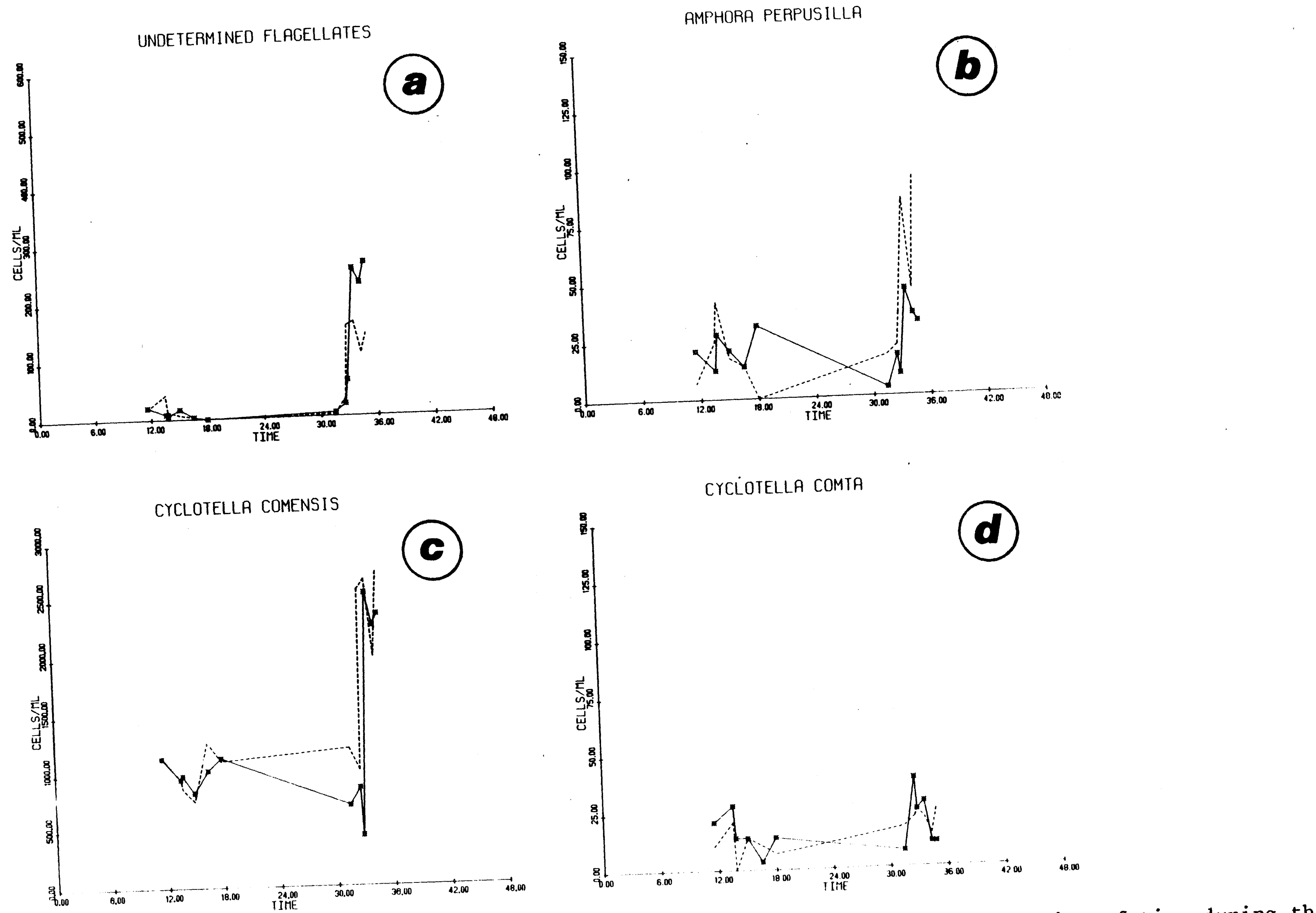


Fig. 12a-p. Alpena - Fall. Cell densities (cells/mL) of selected taxa as a function of time during the 24-hr sampling period. Solid line = lake densities; dashed line = tap densities.

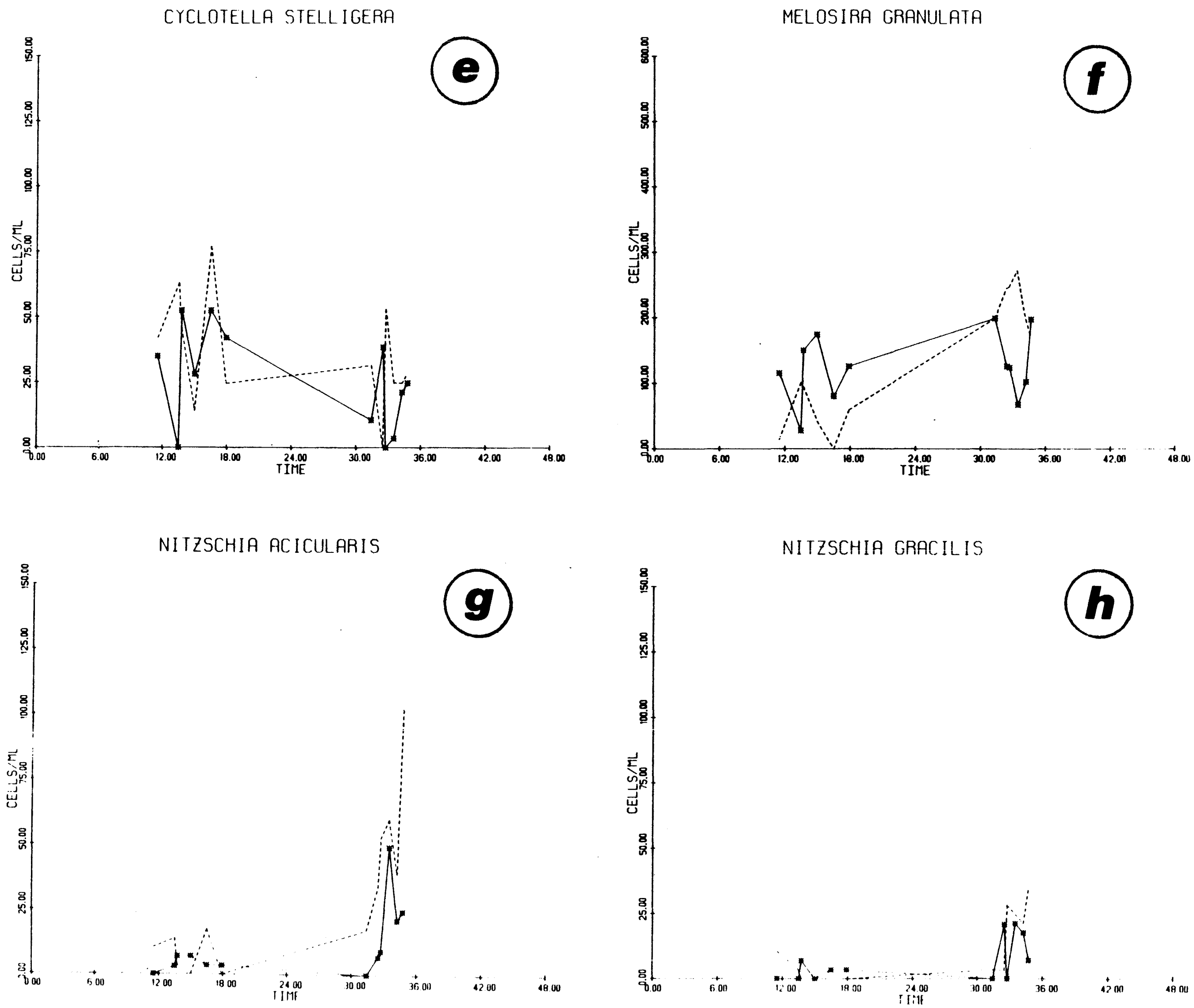


Fig. 12. (continued)

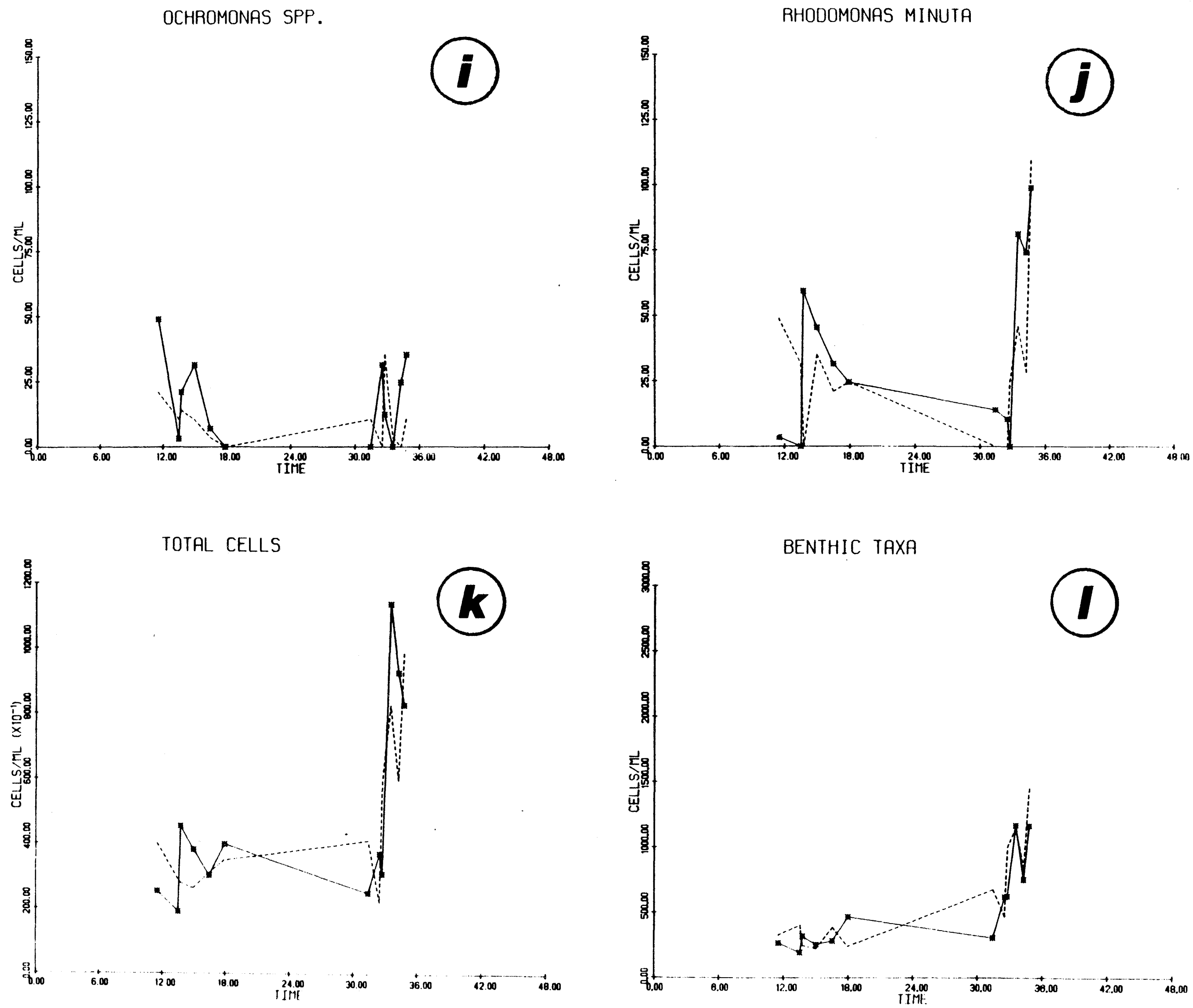
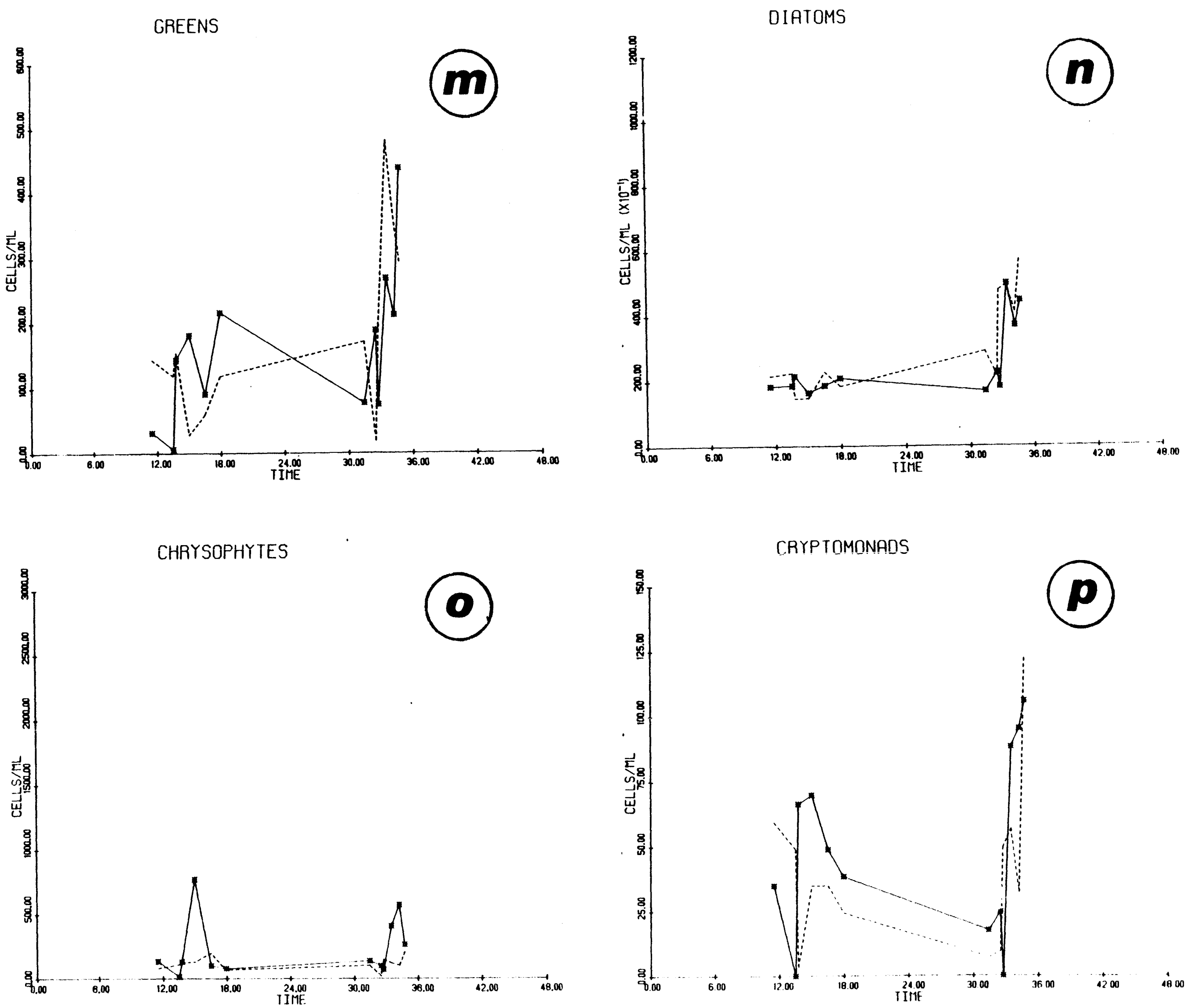


Fig. 12. (continued)



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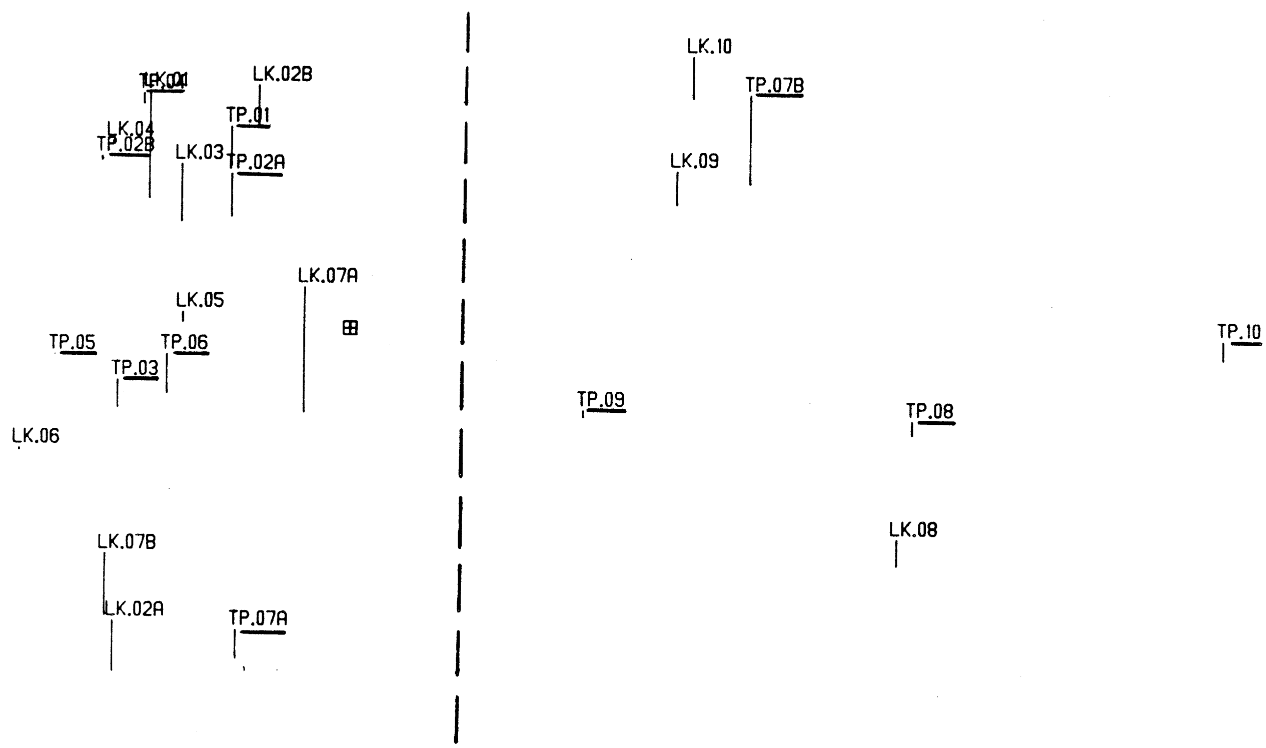

Fig. 13. Alpena - Fall. Plot of lake and tap samples located according to their scores for the first (x-axis), second (y-axis), and third (z-axis) principal components. The x-y position of a given sample is located at the bottom end of the z-coordinate stick. The cross designates the position of the origin. See caption of Figure 7 for more details of the analysis and plotting technique. (a) PCA of individual taxa cell densities: using the variables undetermined flagellates, *Amphora perpusilla*, *Cyclotella comensis*, *C. comta*, *C. stelligera*, *Nitzschia acicularis*, *N. gracilis*, *Ochromonas* spp., and *Rhodomonas minuta*. The dashed line separates lake samples 8-10 and tap samples 7B-10 from the remaining samples. (b) PCA of composite category cell densities: using the variables total density, benthic, undetermined, greens, diatoms, chrysophytes, cryptomonads. The dashed line separates lake samples 8-10 and tap samples 7B-10 from the remaining samples.

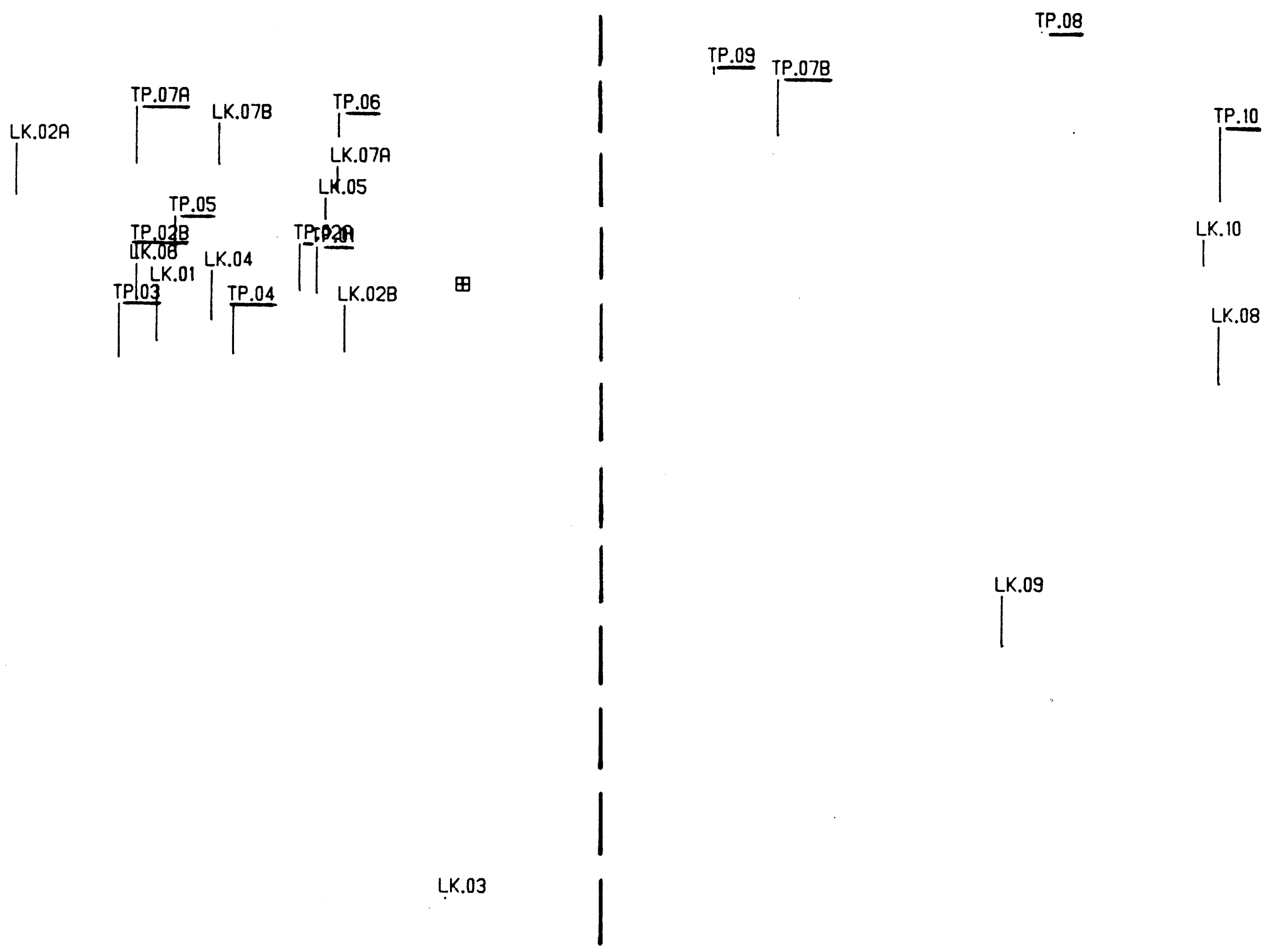

Fig. 13. (continued)

Nitzschia acicularis (Fig. 12g), *N. gracilis* (Fig. 12h), *Amphora perpusilla* (Fig. 12b), and undetermined flagellates (Fig. 12a) show a consistent large increase in abundance at the later sampling times; these taxa exhibited the largest (positive) loadings for PC1 in the PCA of individual taxa densities (Table 9a). *Cyclotella comensis* is an abundant, singly-occurring, readily-identifiable taxon which, if sampled from a homogeneous water mass, generally exhibits standard deviations that are typical of Poisson distributions. In this case a Poisson variate would exhibit a coefficient of variation of less than 10%. However, in these data the density of *C. comensis* increases by a factor of approximately 2.5x in the later samples; the same trend is seen in both lake and tap samples (Fig. 12c). The observed increase is therefore not likely to be the result of random sampling error from a homogeneous water mass. This implies the existence of heterogeneous water masses with rather distinct boundaries in Thunder Bay near the Alpena water intake. The large increase in total density (Fig. 12k) and in benthic taxa such as *Nitzschia acicularis*, *N. gracilis*, and *A. perpusilla* suggests that a distinct water mass, perhaps originating from either bottom water or the Thunder Bay River, flowed over the intake.

The distinct shift in assemblage composition occurred between sampling times 7B and 8 in lake samples and between times 7A and 7B in tap samples; this implies that the method used to pair lake/tap samples may not be accurate enough to guarantee sampling of the same water mass for the lake/tap pairs. The large changes observed between tap samples 7A and 7B occurred within the 15 min "replicate" sampling period, which suggests that 15 min sampling intervals are long relative

TABLE 9. Alpena - Fall. Tables of taxa loadings associated with the first three principal components from PCAs using (a) selected individual taxa cell densities and (b) composite category cell densities. See Figures 13a,b for a more complete description of the PCAs.

TABLE 9a.

	PC1	PC2	PC3
Undetermined flagellates	.38960	.01974	.01926
Amphora perpusilla	.39644	.00273	-.15134
Cyclotella comensis	.43588	.10112	-.07864
C. comta	.16361	-.46081	.63112
C. stelligera	-.04738	.69984	.02072
Nitzschia acicularis	.42259	-.11144	-.08768
N. gracilis	.41743	-.01651	.12799
Ochromonas spp.	.03676	.44815	.72031
Rhodomonas minuta	.34331	.27152	-.16998

TABLE 9b.

	PC1	PC2	PC3
Total density	.43085	-.02663	.12342
Benthic	.40657	.30631	.09765
Undetermined	.40832	.00468	.14450
Greens	.37259	.18814	-.83691
Diatoms	.41376	.26286	.17680
Crysophytes	.20379	-.82461	-.26591
Cryptomonads	.36166	-.34781	.38983

to the time frame within which substantial changes in water mass can occur at this particular sampling site.

ALPENA - WINTER

Results from parallel univariate paired-sample t-tests comparing lake and tap cell densities of selected taxa from Alpena during the winter are summarized in Table 10. Plots of lake/tap cell densities vs. time for the same taxa are presented in Figures 14a-m. Note that only six lake/tap sample pairs were obtained. The undetermined flagellate category (Fig. 14a) was the only taxon found to differ significantly in abundance after entrainment, decreasing from a mean density of 70.1 to 40.1 cells/mL. Many of the taxa exhibited an unusually large variability, with no apparent trend across time or with lake/tap sampling location. Large differences in taxa densities were observed in "replicate" samples, even for taxa which occur singly in the Great Lakes, e.g. in tap samples 1A and 1B the abundance of *Cyclotella comensis* (Fig. 14b) ranged from 226.9 to 73.3 cells/mL and in tap samples 3A and 3B the density of *Cryptomonas* spp. (Fig. 14g) ranged from 115.2 to 12.4 cells/mL. Total cell densities during the 24-hr sampling period were in general very low, ranging from 963.4 to 263.1 cells/mL. From the above evidence it can be concluded that too small an area was scanned on each slide and too few consecutive time points sampled to describe this sparse assemblage very accurately.

The small sample size precluded calculation of Hotelling's T-Square statistic. Plots of the PCAs of individual taxa (Fig. 15a and Table 11a) and composite category abundances (Fig. 15b and Table 11b) show no patterns with time or with lake/tap sampling location. Lake/tap

TABLE 10. Alpena--Winter. Summary of paired sample t-test results comparing lake and tap cell densities of selected taxa from an Alpena winter phytoplankton assemblage. Starred values (*) are significant at α = .05 level using the Bonferroni critical value $t_{\alpha/p;N-1}$. N = 6; p = 14; $t_{\alpha/p;N-1}$ = $t_{.0036;5}$. See Materials and Methods section for more details of the analysis.

	Lake mean cell density (cells/mL)	Tap mean cell density (cells/mL)	Mean difference (lake-tap)	Std dev of difference	t-stat	Attained significance
<u>Individual taxa</u>						
Undetermined flagellates[1]	70.1	40.0	30.1	11.3	6.49	.0013*
Cyclotella comensis	80.8	96.0	-15.2	68.8	-0.54	.6124
C. ocellata	42.5	29.5	13.0	24.9	1.28	.2556
C. stelligera	43.4	57.1	-13.7	52.9	-0.63	.5538
Synedra filiformis	24.9	21.8	3.1	19.2	0.39	.7105
Ochromonas spp.	22.7	13.8	8.9	17.0	1.27	.2595
Cryptomonas spp.	45.1	40.5	4.6	40.2	0.28	.7880
Rhodomonas minuta[2]	102.6	58.9	43.7	104.0	1.03	.3506
<u>Composite categories</u>						
Total cells	603.8	635.1	-31.3	389.0	-0.20	.8516
Benthic	27.5	45.4	-17.9	41.8	-1.05	.3432
Undetermined[1]	70.1	40.0	30.1	11.3	6.49	.0013*
Diatoms	298.8	370.2	-71.4	202.0	-0.87	.4260
Chrysophytes	40.0	41.2	-1.2	28.8	-0.10	.9243
Cryptomonads	147.7	99.4	48.3	131.4	0.90	.4088

[1]"Undetermined" composite category is synonymous with taxon designation "undetermined flagellates."
[2]This category included individuals identified as *Rhodomonas minuta* and as *R. minuta* var. *nannoplanctica*.

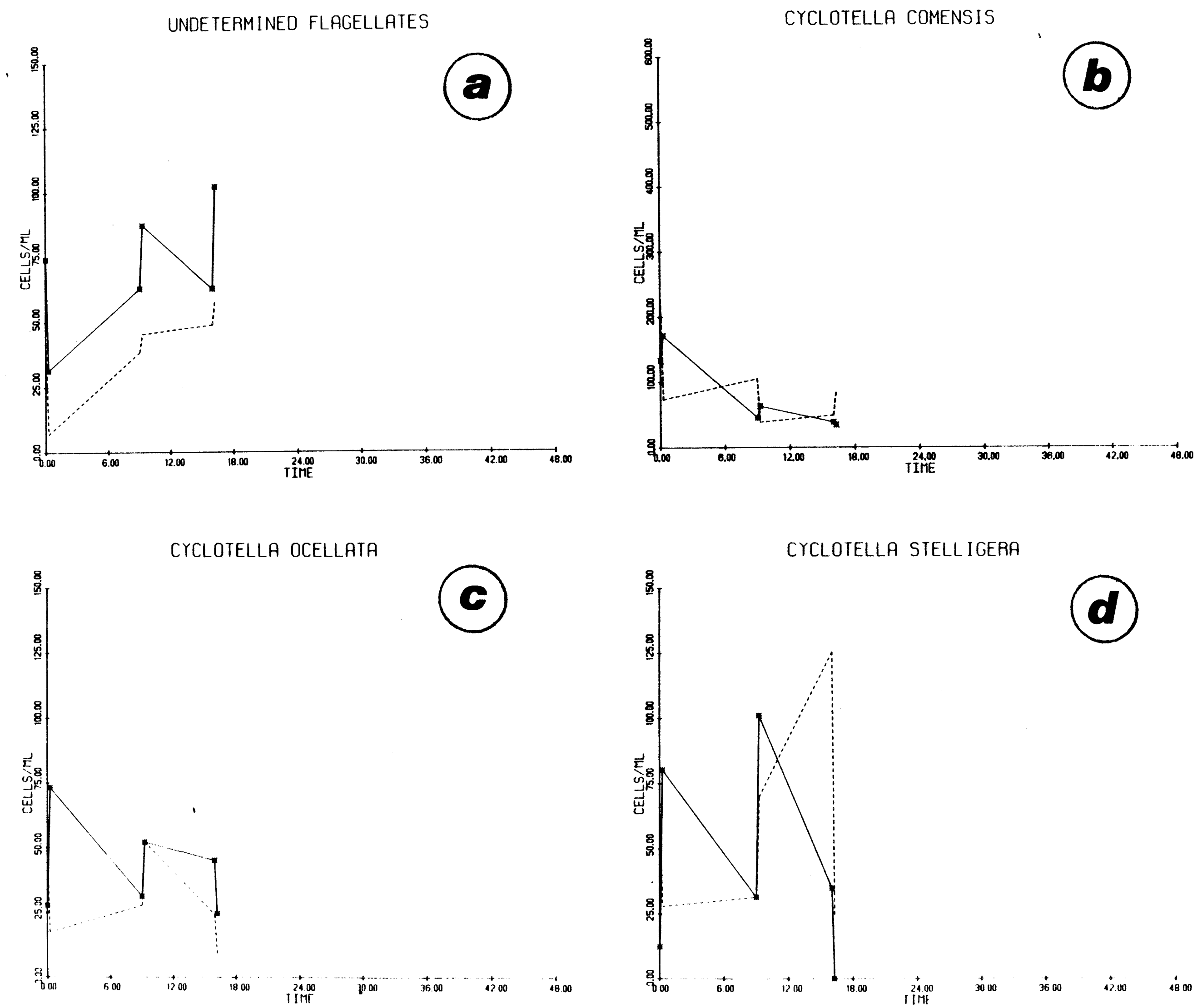

Fig. 14a-m. Alpena - Winter. Cell densities (cells/mL) of selected taxa as a function of time during the 24-hr sampling period. Solid line = lake densities, dashed line = tap densities.

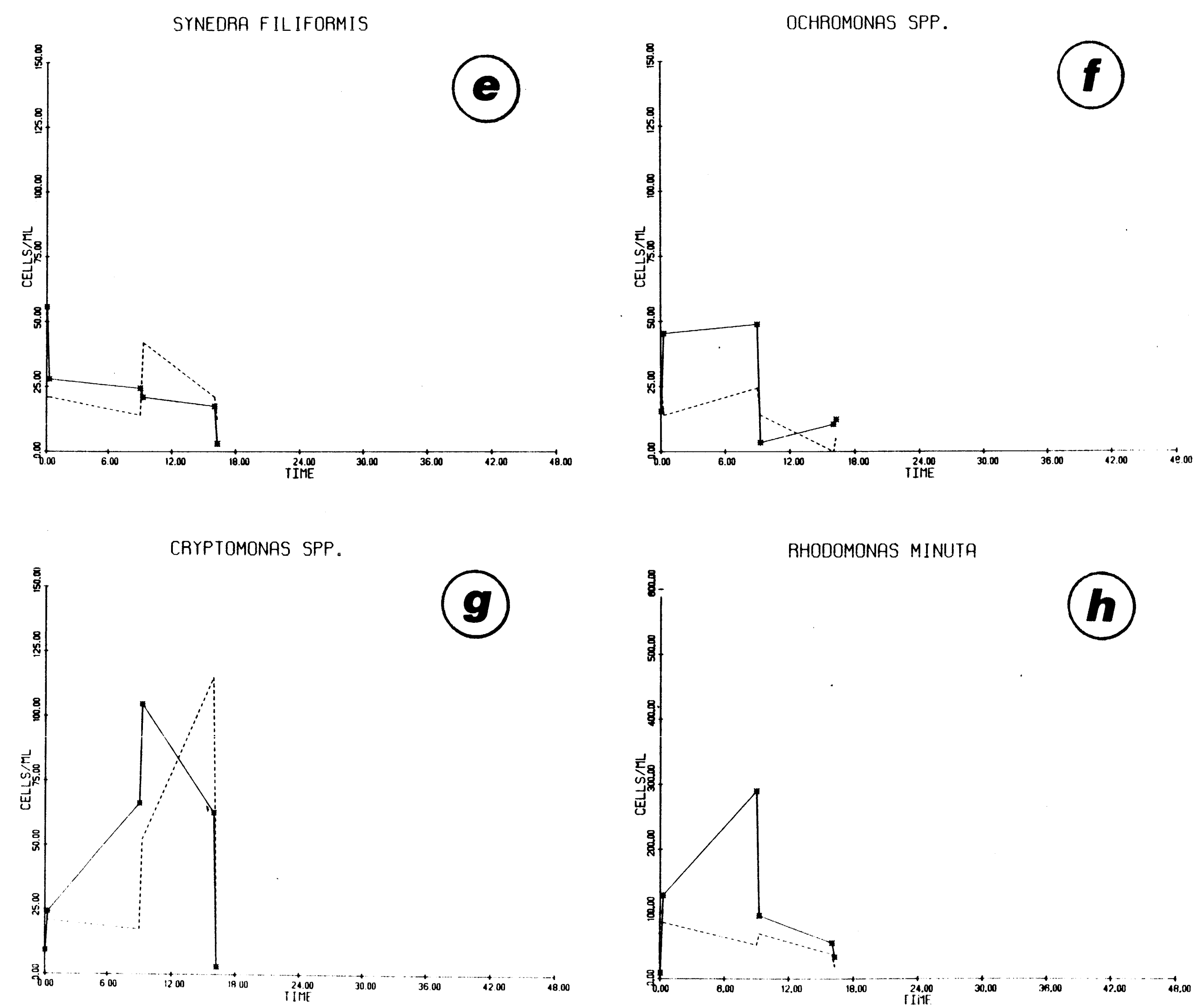

Fig. 14. (continued)

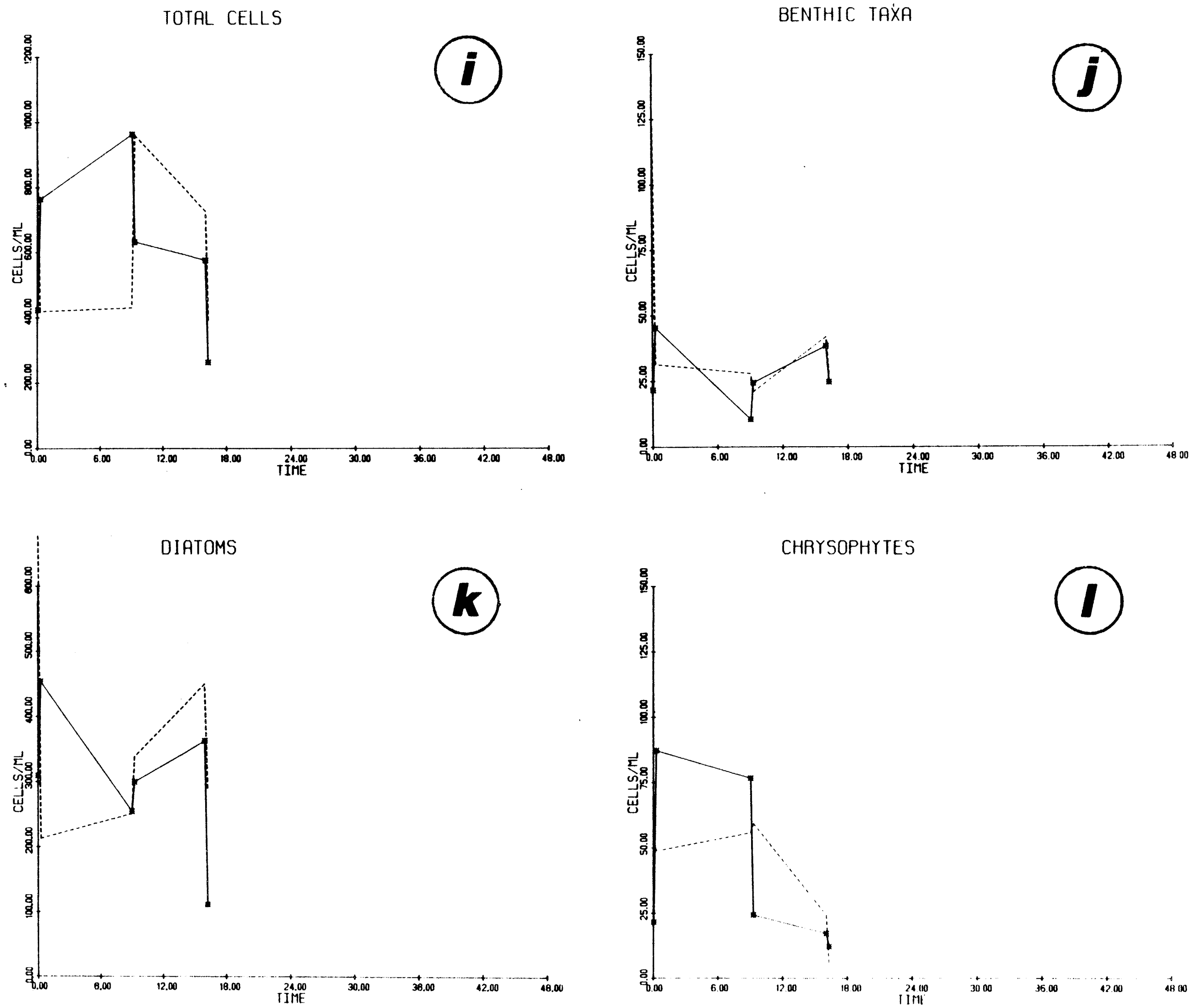

Fig. 14. (continued)

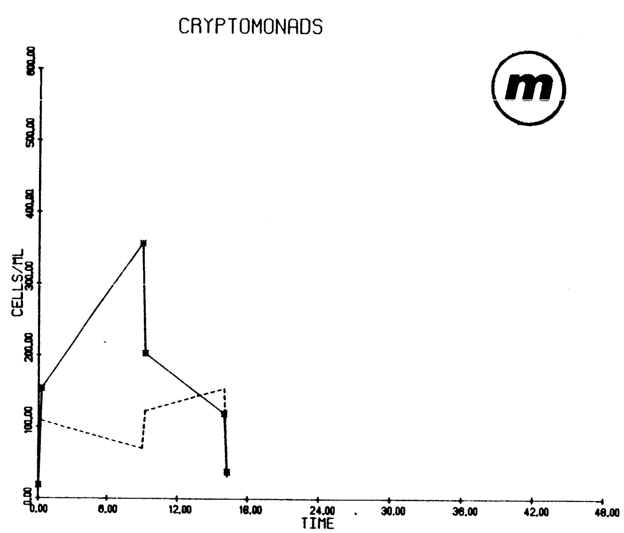

Fig. 14. (continued)

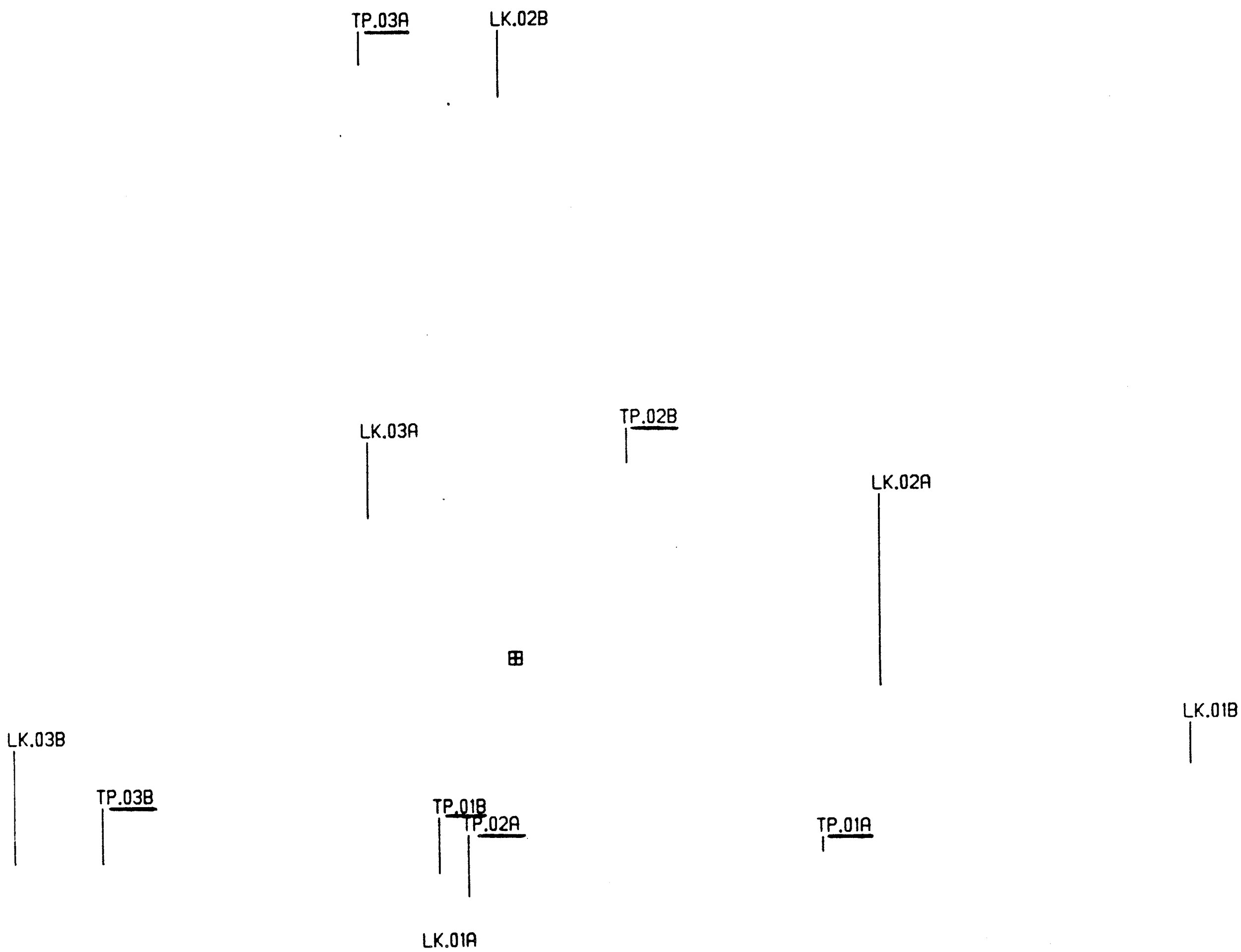

Fig. 15. Alpena - Winter. Plot of lake and tap samples located according to their scores for the first (x-axis), second (y-axis), and third (z-axis) principal components. The x-y position of a given sample is located at the bottom end of the z-coordinate stick. The cross designates the position of the origin. See caption of Figure 7 for more details of the analysis and plotting technique. (a) PCA of individual taxa cell densities: using the variables undetermined flagellates, *Cyclotella comensis, C. ocellata, C. stelligera, Synedra filiformis, Ochromonas* spp., *Cryptomonas* spp., *Rhodomonas minuta*. (b) PCA of composite category densities: using the variables total density, benthic, undetermined, diatoms, chrysophytes, cryptomonads.

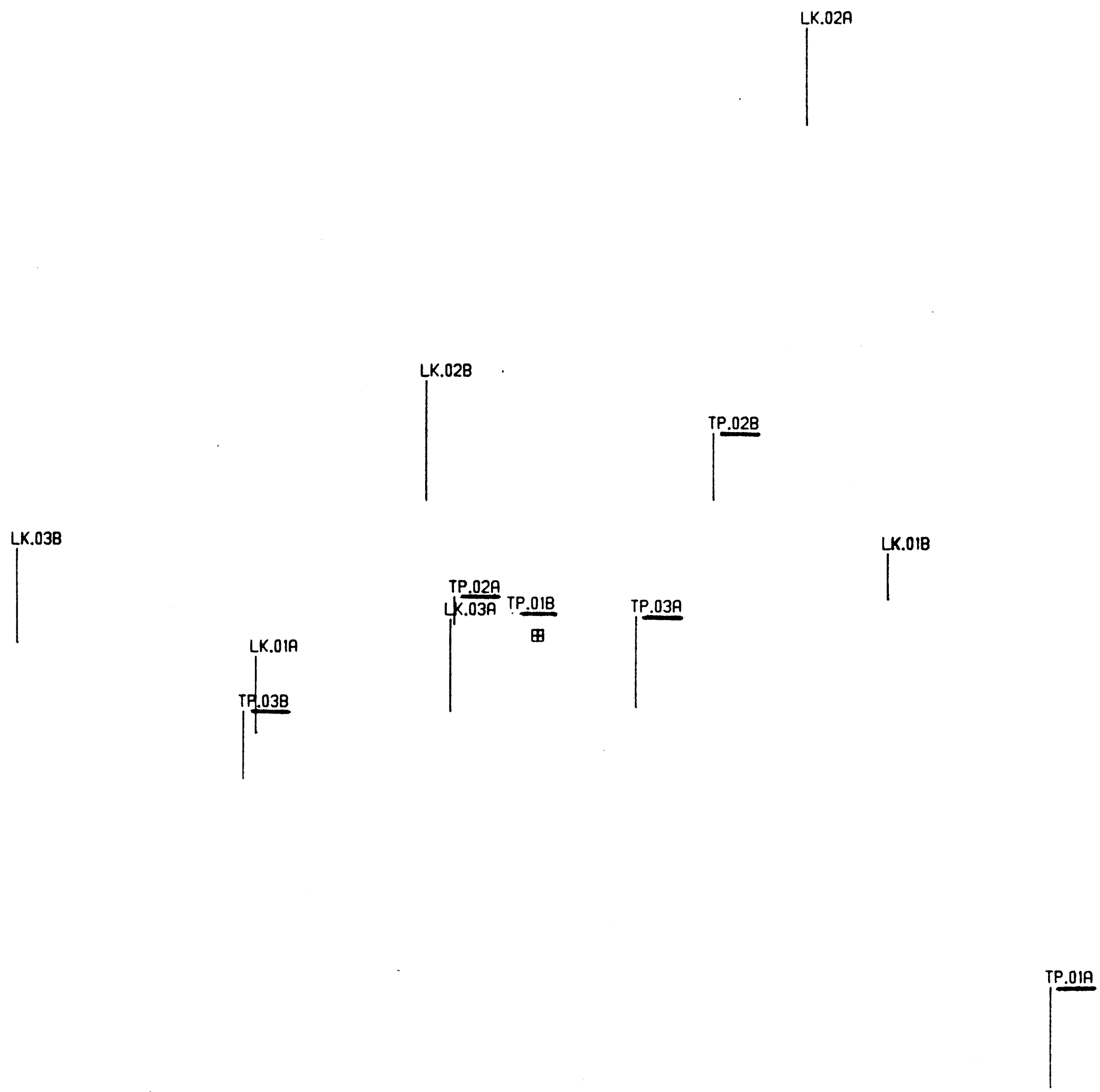

Fig. 15. (continued)

TABLE 11. Alpena - Winter. Tables of taxa loadings associated with the first three principal components from PCAs using (a) selected individual taxa cell densities and (b) composite category cell densities. See Figures 15a,b for a more complete description of the PCAs.

TABLE 11a.

	PC1	PC2	PC3
Undetermined flagellates	-.29105	.13490	.26518
Cyclotella comensis	.34495	-.30668	-.44736
C. ocellata	.47812	.19113	-.12934
C. stelligera	.24630	.56808	-.25709
Synedra filiformis	.24432	-.00688	-.37468
Ochromonas spp.	.50845	-.29712	.35403
Cryptomonas spp.	.07578	.66237	.11672
Rhodomonas minuta	.42788	.03811	.60612

TABLE 11b.

	PC1	PC2	PC3
Total density	.51163	.20624	.30797
Benthic	.33209	-.59479	.15411
Undetermined	-.33842	.09795	.77689
Diatoms	.44662	-.44162	.24684
Crysophytes	.45241	.31069	-.34915
Cryptomonads	.33057	.55003	.30823

sample pairs and consecutive samples across time do not tend to cluster on the plots.

PORT HURON AND ALPENA - ALL SEASONS

Composite category cell densities from both sampling sites and all seasons were merged, to allow comparision of the relative magnitudes of location, season, and lake/tap differences. Principal component analysis of composite category densities (Fig. 16) was used to summarize similarities between samples. The first principal component (PC1) in general separates Alpena samples by season. The samples cluster rather distinctly and follow an orderly progression from summer to fall to winter with decreasing PC1 score. There is no apparent lake/tap separation within these seasonal clusters. The unusual set of samples from the Alpena fall dataset (lake samples 8, 9, and 10 and tap samples 7B, 8, 9, and 10) form a distinct cluster with high scores for both PC1 and PC2. The unusually clean water found under the ice during the winter sampling at Alpena clusters with the Port Huron summer and spring tap samples. PC2 generally separates Port Huron summer and spring lake samples from the corresponding tap samples. Although the lake/tap clusters show some overlap, lake samples in general have larger scores for PC2 than the corresponding paired tap samples. There is no apparent seasonal separation within the Port Huron lake and tap clusters.

Total density, diatoms, benthic taxa, and greens all exhibit large positive loadings for PC1 (Table 12); cryptomonads, chrysophytes, and undetermined flagellates exhibit negative loadings rather close to zero. Thus the major difference between seasons at Alpena is characterized by a general decrease in total, diatom, and green densities from summer to

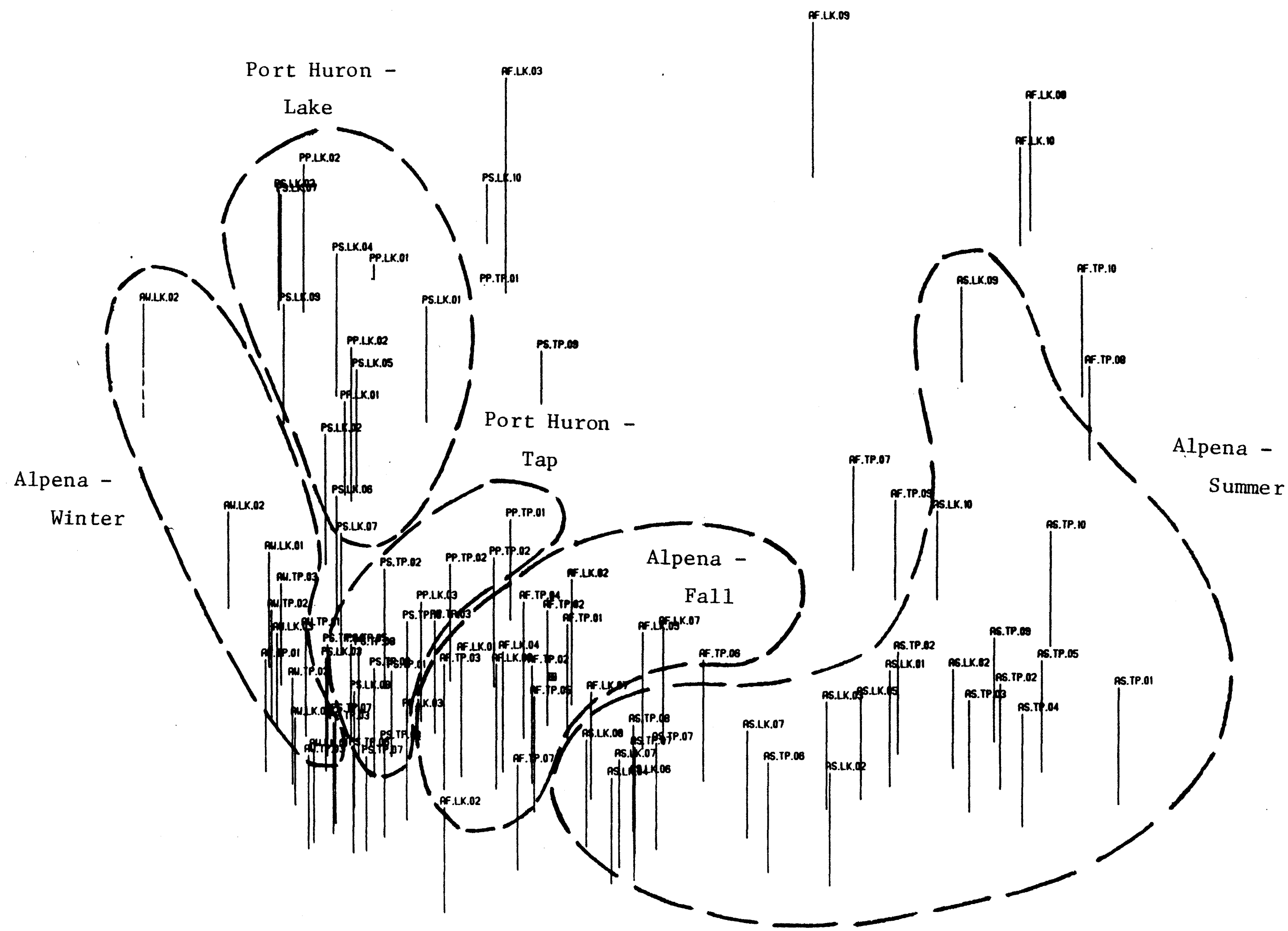

Fig. 16. Port Huron and Alpena - Summer, Fall, Winter, Spring. Plot of all samples located according to their scores for the first (x-axis), second (y-axis), and third (z-axis) principal components. Taxa utilized included: total density, benthic, undetermined, greens, diatoms, chrysophytes, cryptomonads. The x-y position of a given sample is located at the bottom end of the z-coordinate stick. The cross designates the position of the origin. See caption of Figure 7 for more details of the analysis and plotting technique.

TABLE 12. Port Huron and Alpena - Summer, Fall, Winter, Spring. Tables of taxa loadings associated with the first three principal components from PCA of composite category cell densities. See Figure 16 for a more complete description of the PCA.

	PC1	PC2	PC3
Total density	.52431	.10131	.09515
Benthic	.48910	.06258	.08961
Undetermined	-.01826	.57483	-.69790
Greens	.41458	.27592	-.12909
Diatoms	.50806	-.08095	-.00081
Crysophytes	-.05633	.56778	.68964
Cryptomonads	-.22887	.50034	.05980

winter (Figs. 4a,b,c); cryptomonads, chrysophytes, and undetermined flagellates exhibit the reverse trend, with densities of chrysophytes and undetermined flagellates peaking in the fall (Figs. 4e,f) and cryptomonads in the winter (Fig. 4d). The largest (positive) loadings for PC2 are associated with undetermined flagellates, chrysophytes, and cryptomonads; all other loadings are very close to zero. The summer and spring samples from Port Huron are very similar in total density (Fig. 2a) and assemblage composition (Fig. 3a,b). However, lower densities of undetermined flagellates (Fig. 2f), chrysophytes (Fig. 2e), and cryptomonads (Fig. 2d) were generally observed in Port Huron tap samples.

CONCLUSIONS

Results from both water intakes and all seasons analyzed are summarized in Table 13. The data suggest that small but consistent changes can occur in phytoplankton assemblages following entrainment in water treatment facilities. The type of effect observed seems to vary depending on the season and on the characteristics of the water intake system. Port Huron tap samples from both summer and spring showed a consistent (though not always statistically significant) decrease in abundance of several flagellated taxa; summer tap samples from Port Huron exhibited a weak trend (which was not statistically significant) toward increased densities of benthic taxa compared to lake samples. Similar effects were observed in the Alpena samples, but lake/tap differences at Alpena were in general less pronounced. Undetermined flagellates decreased significantly in winter tap samples from Alpena; summer tap samples contained consistently higher densities

TABLE 13. Port Huron and Alpena--Summer, Fall, Winter, Spring. Summary of results of analyses comparing lake and tap samples. Statistically significant (P > .95) differences are marked by an asterisk; trends that were not statistically significant are marked by a dagger.

Water intake	Season	Effect observed	Significance
Port Huron	Summer	Lake samples contained higher densities of *Rhodomonas minuta*, chrysophytes and cryptomonads.	*
		Lake samples contained higher densities of undetermined flagellates.	†
		Tap samples contained higher densities of benthic taxa.	†
		Lake and tap assemblages as described by division densities were significantly different (multivariate Hotelling's T-square test)	*
	Spring	Lake samples contained higher densities of cryptomonads.	†
		Lake samples contained higher densities of *Rhodomonas minuta* and *Cryptomonas* spp.	†
Alpena	Summer	Tap samples contained higher densities of *Melosira granulata* and benthic taxa.	†
		Lake and tap assemblages as described by selected species densities were significantly different (multivariate Hotelling's T-square test)	*
	Fall	No significant lake/tap differences or trends observed.	
		Possible change in water mass occurred during 24-hr sampling.	†
	Winter	Lake samples contained higher densities of undetermined flagellates.	*
		Many taxa exhibited unusually large variability, probably due to small sample size.	†

of benthic taxa compared to lake samples, although the trend was not statistically significant.

However, lake/tap differences in taxon abundance were, in general, small. Port Huron lake and tap samples both show common seasonal patterns in taxon abundance which differ markedly from the patterns observed at Alpena (compare Figs. 2 and 3 with Figs. 4 and 5 respectively). The principal component analysis incorporating all data (Fig. 16) suggests that variation in taxon abundances due to lake/tap effects is small compared with variation due to season and location.

Several characteristics of the water intake systems probably exert small but measurable effects on entrained phytoplankton assemblages, e.g. (1) the depth of the intake crib; (2) the transit time required for a slug of lakewater to travel the length of the intake pipe; (3) type and abundance of plant growth on the intake crib; (4) the size and flushing time of the reservoir (if there is one) from which the tap samples are taken. The crib depth at Port Huron is 45 ft, at Alpena 16 ft. The water transit time at Port Huron is approximately 8 hr 45 min, at Alpena approximately 30 min. The type and abundance of periphyton on the crib were not determined for either site; the tap samples were taken directly from the intake pipe at both locations. The distinct flagellate effect observed at Port Huron and the lesser effect seen at Alpena may be caused by (1) a very specific depth preference of the flagellates which is not sampled by the intake, (2) an avoidance response to the intake current, or (3) the long transit time in the pipe. The current data do not permit selection or rejection of any of the above hypotheses; however, the difference in magnitude of the flagellate effects observed at Port Huron and Alpena suggests that the

very long water transit time at Port Huron may be an important factor. The shallow depth of the crib at Alpena may encourage summer periphyton growth, accounting for the trend toward increases in benthic taxa observed in the summer Alpena tap samples.

The large unexplained variability found in the Alpena lake samples from all seasons suggests that too few cells were counted on each slide and that too few slides were counted to distinguish anything but very gross changes in cell density. Several abundant taxa (e.g. *Anacystis incerta*, *Gomphosphaeria lacustris*, *Fragilaria crotonensis*, *F. pinnata*) were not included in the analyses because of a large colony-size-to-cells-counted ratio. The time interval between "replicate" samples at Alpena was long relative to the potential patchiness of the lake; such "replicates" did not permit separating true lake patchiness from variability contributed by the sampling, slide making, and enumeration techniques. Thus, although a few systematic differences were found between lake and tap samples at the two locations, an expanded experimental design which counted each slide to a greater accuracy, included true replicate samples in order to estimate the error variance, and had a consistent design across seasons and locations would increase the power of the statistical tests.

Comparison of results from the Port Huron and Alpena analyses raises a more general issue: assessing the appropriateness of a given monitoring site. One important aspect of that assessment is whether entrainment at the given site significantly alters the phytoplankton assemblage. However, the data demonstrate that other considerations are also significant.

1) Does the water intake sample a water mass that is representative of the body of water to be monitored? This question is particularly relevant to water intake sampling, since many intakes are located in nearshore waters, close to highly populated areas. Schelske and Roth (1973) found that the phytoplankton assemblage of Saginaw Bay differed drastically from the rest of Lake Huron both quantitatively and qualitatively. Lowe (1976) found much higher phytoplankton abundances in Thunder Bay than at comparable stations in other parts of northern Lake Huron.

2) Does the water intake sample a fairly homogeneous water mass or do widely differing water masses or sources of contamination impinge on the intake depending on the weather conditions? Are seasonal variations so great that a representative sample is difficult to obtain? Stoermer (1967) suggested using comparisons of offshore flora for long-term environmental monitoring since (1) offshore plankton undoubtedly constitute the major portion of the biomass of the lake; and (2) the offshore environment is more stable, i.e. changes in flora will be less subject to wide fluctuations resulting from transient conditions and therefore more indicative of long-term environmental changes. The large change in assemblage composition that occurred within a 15 min period during the Alpena fall sampling period suggests that the Thunder Bay River plume may impinge on the Alpena water intake. The Thunder Bay phytoplankton assemblage also exhibits qualitative and quantitative changes with season that are much more pronounced than in the open lake (open lake data from Stoermer and Kreis 1980).

3) What are the implications of sampling at a single fixed depth? Nicholls et al. (1980) discussed the problem of sampling at a single

depth, especially when that depth is fixed relative to the bottom rather than the surface, as is the case with water intakes. They found the long-term annual averages of dinoflagellates in Lake Erie to be highly correlated with lake level, suggesting that the intake may be sampling the preferred depth for dinoflagellates only at certain lake levels.

Thus this study suggests that an appropriate water intake long-term monitoring site should have the following characteristics:

(1) entrainment does not significantly change (or changes in a consistent, predictable fashion) the phytoplankton populations of interest;

(2) the water around the intake is representative of the body of water being monitored;

(3) the phytoplankton assemblage responds conservatively to short-term environmental perturbations and long-term seasonal changes;

(4) intake depth does not force the sampling of a different assemblage when lake level or the season changes.

The current preliminary study suggests that the Alpena intake may fail on the basis of criteria 2 through 4. The Port Huron intake exhibits several fairly consistent lake/tap differences (possible violations of criterion 1), but a more complete sampling scheme is required to assess the relative importance and predictability of those differences.

In any case it is clear from the results of this study that intake monitoring localities should be carefully chosen with a clear understanding of the specific questions any long-term monitoring effort should answer. Certain localities and physical structures will be optimal for detecting long-term and gradual shifts in the biota of

significant importance to the entire lake. Others will be optimal for detecting extreme or unusual events which may seriously affect local or regional water quality. Both capabilities are important to effective water quality management, and it may well be that the best design for long-term monitoring would contain more than one station per lake.

The fact that departures from perfect representation of lake conditions are detectable in the tap samples should not be viewed as discouraging. It is quite clear, *a priori*, that such effects must occur at some level. The real question is whether entrainment effects can be separated from sampling error and purely random variation. It is clear from our results that this is possible. This indicates that a carefully and thoughtfully designed intake sampling program could be a powerful tool for monitoring Great Lakes water quality.

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APPENDICES

APPENDIX I. Taxonomic list of all taxa identified, including authorities.

APPENDIX II. List of DNR and corresponding UM sample numbers.

APPENDIX III. "SUMMARY" output from the database management system "FIDO", tabulating mean and maximum taxon cell densities for each location*season*tap/lake (i.e. Port Huron-Summer-Lake, Port Huron-Summer-Tap, etc.)

APPENDIX I. Taxonomic list of all taxa identified, including authorities.

UNDETERMINED

Undetermined flagellate spp.

CYANOPHYTA

Agmenellum quadruplicatum (Menegh.) Bréb.
Anabaena flos-aquae (Lyngb.) Kütz.
Anabaena spp.
Anacystis incerta (Lemm.) Dr. and Daily
Anacystis spp.
Anacystis thermalis (Menegh.) Dr. and Daily
Gomphosphaeria lacustris Chod.
Oscillatoria bornetii Zukal
Oscillatoria spp.
Undetermined blue-green filament

CHLOROPHYTA

Ankistrodesmus sp. #3
Ankistrodesmus spp.
Botryococcus braunii Kütz.
Chlamydomonas spp.
Cosmarium spp.
Crucigenia quadrata Morren
Crucigenia spp.
Gloeocystis planctonica (W. and W.) Lemm.
Lagerheimia spp.
Mougeotia sp. #1
Oocystis spp.
Pediastrum boryanum (Turp.) Menegh.
Pediastrum duplex Meyen
Pediastrum integrum Näg.
Pediastrum spp.
Pediastrum tetras (Ehr.) Ralfs
Quadrigula spp.
Scenedesmus bicellularis Chod.
Scenedesmus bijuga (Turp.) Lag.
Scenedesmus carinatus (Lemm.) Chod.
Scenedesmus quadricauda (Turp.) Bréb.
Scenedesmus serratus (Chod.) Bohn.
Scenedesmus spinosus Chod.
Scenedesmus spp.
Spondylosium planum (Wolle) W. and W.
Tetraedron minimum (A. Br.) Hansg.
Ulothrix spp.
Ulothrix zonata (Weber and Mohr.) Kütz.
Undetermined green colonies
Undetermined green filaments
Undetermined green individual

BACILLARIOPHYTA

Achnanthes biasolettiana (Kütz.) Grun.
Achnanthes clevei var. *rostrata* Hust.

Achnanthes exigua Grun.
Achnanthes lanceolata var. *dubia* Grun.
Achnanthes lanceolata var. *omissa* Reim.
Achnanthes spp.
Actinocyclus normanii fo. *subsalsa* (Juhl.-Dannf.) Hust.
Amphora ovalis var. *affinis* (Kütz.) V.H.
Amphora ovalis var. *pediculus* (Kütz.) V.H.
Amphora ovalis (Kütz.) Kütz.
Amphora perpusilla (Grun.) Grun.
Amphora spp.
Amphora thumensis (Mayer) A.Cl.
Asterionella formosa Hass.
Caloneis spp.
Cocconeis diminuta Pant.
Cocconeis placentula var. *euglypta* (Ehr.) Cl.
Cyclotella antiqua W. Sm.
Cyclotella comensis Grun.
Cyclotella comta (Ehr.) Kütz.
Cyclotella kuetzingiana Thw.
Cyclotella meneghiniana Kütz.
Cyclotella michiganiana Skv.
Cyclotella ocellata Pant.
Cyclotella operculata (Ag.) Kütz.
Cyclotella pseudostelligera Hust.
Cyclotella spp.
Cyclotella stelligera (Cl. and Grun.) V.H.
Cymatopleura solea (Bréb. and Godey) W. Sm.
Cymbella cistula (Ehr.) Kirchn.
Cymbella microcephala Grun.
Cymbella minuta Hilse
Cymbella minuta fo. *latens* (Krasske) Reim.
Cymbella spp.
Cymbella triangulum (Ehr.) Cl.
Denticula spp.
Denticula tenuis var. *crassula* (Näg. and Kütz.) W. and G.S. West
Diatoma tenue var. *elongatum* Lyngb.
Diploneis oculata (Bréb.) Cl.
Diploneis parma Cl.
Entomoneis ornata (J.W. Bail.) Reim.
Fragilaria brevistriata Grun.
Fragilaria capucina Desm.
Fragilaria construens (Ehr.) Grun.
Fragilaria construens var. *binodis* (Ehr.) Grun.
Fragilaria crotonensis Kitton
Fragilaria intermedia Grun.
Fragilaria intermedia var. *fallax* (Grun.) A. Cl.
Fragilaria leptostauron (Ehr.) Hust.
Fragilaria leptostauron var. *dubia* (Grun.) Hust.
Fragilaria pinnata var. *lancettula* (Schum.) Hust.
Fragilaria pinnata Ehr.
Fragilaria spinosa Skv.
Fragilaria spp.
Fragilaria vaucheriae (Kütz.) Peters.
Gomphonema olivaceum (Lyngb.) Kütz.
Gomphonema spp.
Mastogloia spp.
Melosira distans var. *alpigena* Grun.
Melosira granulata alpha status (Ehr.) Ralfs
Melosira granulata var. *angustissima* O. Müll.
Melosira granulata (Ehr.) Ralfs

Melosira islandica O. Müll.
Navicula capitata (Ehr.)
Navicula capitata var. *luneburgensis* (Grun.) Patr.
Navicula cryptocephala var. *veneta* (Kütz.) Rabh.
Navicula cryptocephala Kütz.
Navicula jaernefeltii Hust.
Navicula pupula Kütz.
Navicula radiosa var. *tenella* (Bréb.) Cl. and Moll.
Navicula radiosa Kütz.
Navicula scutelloides W. Sm.
Navicula spp.
Navicula stroesei A. Cl.
Navicula tripunctata (O.F. Müll.) Bory
Neidium dubium fo. *constrictum* Hust.
Neidium dubium (Ehr.) Cl.
Nitzschia acicularis (Kütz.) W. Sm.
Nitzschia acuta Hantz.
Nitzschia angustata var. *acuta* Grun.
Nitzschia confinis Hust.
Nitzschia denticula Grun.
Nitzschia dissipata (Kütz.) Grun.
Nitzschia fonticola Grun.
Nitzschia gracilis Hantz.
Nitzschia sigmoidea (Nitz.) W. Sm.
Nitzschia spiculoides Hust.
Nitzschia spp.
Nitzschia sublinearis Hust.
Rhizosolenia eriensis H.L. Sm.
Rhizosolenia gracilis H.L. Sm.
Rhizosolenia statospore
Stephanodiscus alpinus Hust.
Stephanodiscus binderanus (Kütz.) Krieg.
Stephanodiscus niagarae Ehr.
Stephanodiscus spp.
Surirella angusta Kütz.
Surirella spp.
Synedra acus Kütz.
Synedra cyclopum Brutschy
Synedra filiformis Grun.
Synedra parasitica (W. Sm.) Hust.
Synedra spp.
Synedra ulna var. *danica* (Kütz.) V.H.
Synedra ulna (Nitz.) Ehr.
Tabellaria fenestrata (Lyngb.) Kütz.
Tabellaria fenestrata var. *geniculata* A. Cl.
Tabellaria flocculosa (Roth) Kütz.
Tabellaria flocculosa var. *linearis* Koppen

CHRYSOPHYTA

Chrysococcus dokidophorus Pasch.
Chrysococcus rufescens Klebs
Chrysosphaerella longispina Lautb.
Dinobryon cyst
Dinobryon divergens Imhof
Dinobryon spp.
Kephyrion spp.
Mallomonas spp.
Mallomonas statospore

Mallomonas tonsurata var. *alpina* (Pasch. and Ruttn.) Krieg.
Monochrysis aphanaster Skuja
Ochromonas spp.
Spiniferomonas spp.
Uroglenopsis americana (Calkins) Lemm.

CRYPTOPHYTA

Cryptomonas erosa Ehr.
Cryptomonas ovata Ehr.
Cryptomonas spp.
Rhodomonas minuta Skuja
Rhodomonas minuta var. *nannoplanctica* Skuja

PYRROPHYTA

Ceratium hirundinella (O.F. Müll.) Shrank
Gymnodinium helveticum Penard
Gymnodinium spp.

EUGLENOPHYTA

Euglena spp.
Phacus spp.
Trachelomonas spp.

APPENDIX II. List of DNR and corresponding UM sample numbers.

PORT HURON

Lake Huron				Water Intake - Tap			
UM#	DNR#	Time	Date	UM#	DNR#	Time	Date
0111	101	1110	8-8-80	0211	201	1955	8-8-80
0121	102A	1320	8-8-80	0221	202A	2205	8-8-80
0122	102C	1355	8-8-80	0222	202C	2234	8-8-80
0131	103	1600	8-8-80	0231	203	0045	8-9-80
0141	104	1800	8-8-80	0241	204	0245	8-9-80
0151	105	1930	8-8-80	0251	205	0415	8-9-80
0161	106	2100	8-8-80	0261	206	0545	8-9-80
0171	107A	2230	8-8-80	0271	207A	0715	8-9-80
0172	107C	2300	8-8-80	0272	207C	0745	8-9-80
0181	108	2400	8-8-80	0281	208	0845	8-9-80
0191	109	0130	8-9-80	0291	209	1015	8-9-80
0101	110	0300	8-9-80	0201	210	1145	8-9-80
				1211	1201	1820	10-7-80
				1221	1202A	2030	10-7-80
				1231	1203	2230	10-7-80
1141	1104	1700	10-7-80	1241	1204	0200	10-8-80
1151	1105	1900	10-7-80	1251	1205	0400	10-8-80
1161	1106	2030	10-7-80	1261	1206	0530	10-8-80
				1271	1207A	2130	10-8-80
				1281	1208	2230	10-8-80
				1291	1209	2330	10-8-80
				1201	1210	0030	10-9-80
2111	2101A	1830	5-18-81	2211	2201A	0330	5-19-81
2112	2101C	1900	5-18-81	2212	2201C	0400	5-19-81
2121	2102A	0900	5-19-81	2221	2202A	1800	5-19-81
2122	2102C	0930	5-19-81	2222	2202C	1830	5-19-81
2131	2103A	1300	5-19-81	2231	2203A	2200	5-19-81
2132	2103C	1330	5-19-81	2232	2203C	2230	5-19-91

ALPENA

Lake Huron				Water intake - Tap			
UM#	DNR#	Time	Date	UM#	DNR#	Time	Date
0311	301	1550	8-25-80	0411	401	1630	8-25-80
0321	302A	1730	8-25-80	0421	402A	1800	8-25-80
0322	302C	1800	8-25-80	0422	402C	1830	8-25-80
0331	303	1900	8-25-80	0431	403	1930	8-25-80
0341	304	2030	8-25-80	0441	404	2100	8-25-80
0351	305	2200	8-25-80	0451	405	2230	8-25-80
0361	306	2330	8-25-80	0461	406	2400	8-25-80
0371	307A	0800	8-26-80	0471	407A	0830	8-26-80
0372	307C	0830	8-26-80	0472	407C	0900	8-26-80
0381	308	0930	8-26-80	0481	408	1000	8-26-80
0391	309	1100	8-26-80	0491	409	1130	8-26-80
0301	310	1230	8-26-80	0401	410	1300	8-26-80
1311	1301	1130	10-14-80	1411	1401	1200	10-14-80
1321	1302A	1330	10-14-80	1421	1402A	1400	10-14-80
1322	1302C	1345	10-14-80	1422	1402C	1415	10-14-80
1331	1303	1500	10-14-80	1431	1403	1530	10-14-80
1341	1304	1630	10-14-80	1441	1404	1700	10-14-80
1351	1305	1755	10-14-80	1451	1405	1825	10-14-80
1361	1306	0725	10-15-80	1461	1406	0755	10-15-80
1371	1307A	0830	10-15-80	1471	1407A	0900	10-15-80
1372	1307C	0845	10-15-80	1472	1407C	0915	10-15-80
1381	1308	0930	10-15-80	1481	1408	1000	10-15-80
1391	1309	1015	10-15-80	1491	1409	1045	10-15-80
1301	1310	1045	10-15-80	1401	1410	1115	10-15-80
2311	2301A	0001	2-9-81	2411	2401A	0054	2-9-81
2312	2301C	0016	2-9-81	2412	2401C	0109	2-9-81
2321	2302A	0900	2-9-81	2421	2402A	0953	2-9-81
2322	2302C	0915	2-9-81	2422	2402C	1008	2-9-81
2331	2303A	1600	2-9-81	2431	2403A	1653	2-9-81
2332	2303C	1615	2-9-81	2432	2403C	1708	2-9-81

APPENDIX III. Port Huron-Summer-Lake "SUMMARY"

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  file name       F#
>DNR8007PSOUT      1
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name	number slides	average density	& % pop.	maximum density	& % pop.
Undetermined flagellate spp..	11	132.748	8.386	356.517	15.906
total undetermined (1 categories) . .		132.748	8.386		

name	number slides	average density	& % pop.	maximum density	& % pop.
Anabaena flos-aquae	3	21.768	1.524	197.673	12.389
Anacystis incerta	4	105.359	5.709	498.321	25.968
Anacystis thermalis	9	20.717	1.367	89.760	4.677
Gomphosphaeria lacustris.	2	54.713	2.089	631.848	23.277
Undetermined blue-green filament.	1	3.530	0.157	42.359	1.890
total blue-green (5 categories) . .		206.086	10.846		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ankistrodesmus sp. #3	1	0.294	0.019	3.530	0.231
Ankistrodesmus spp.	3	1.471	0.109	10.590	0.664
Cosmarium spp..	1	0.258	0.013	3.095	0.161
Crucigenia quadrata	3	7.648	0.524	49.418	3.233
Crucigenia spp.	1	2.942	0.397	35.299	4.762
Gloeocystis planctonica	10	52.477	3.509	218.852	9.764
Oocystis spp.	8	13.237	0.945	56.478	2.857
Pediastrum spp.	1	0.588	0.082	7.060	0.985
Scenedesmus bijuga.	3	5.005	0.269	24.761	1.290
Scenedesmus quadricauda	4	5.883	0.362	28.239	2.312
Scenedesmus spp..	5	11.766	0.926	42.359	3.810
Tetraedron minimum.	2	2.353	0.178	24.709	1.795

Undetermined green colonies	3	9.119	0.482	49.418	3.333
Undetermined green individual	3	4.412	0.277	45.888	2.876
total green (14 categories) . .		117.454	8.093		

name	number slides	average density	& % pop.	maximum density	& % pop.
Achnanthes clevei var. rostrata	1	0.294	0.021	3.530	0.256
Achnanthes spp.	1	2.353	0.087	28.239	1.040
Amphora ovalis.	4	1.177	0.091	3.530	0.323
Amphora perpusilla.	3	1.471	0.091	10.590	0.664
Asterionella formosa.	1	1.177	0.074	14.120	0.885
Cocconeis placentula var. euglypta.	1	0.294	0.011	3.530	0.130
Cyclotella comensis	12	474.983	37.838	649.497	65.238
Cyclotella comta.	7	3.236	0.324	10.590	1.429
Cyclotella michiganiana	1	0.294	0.011	3.530	0.130
Cyclotella ocellata	6	2.317	0.134	10.590	0.472
Cyclotella operculata	3	1.177	0.110	7.060	0.685
Cyclotella spp.	1	10.059	0.524	120.711	6.290
Cyclotella stelligera	10	15.296	1.150	31.769	2.381
Cymbella cistula.	1	0.294	0.011	3.530	0.130
Diatoma tenue var. elongatum.	1	0.294	0.018	3.530	0.221
Fragilaria construens	3	6.621	0.283	35.299	1.575
Fragilaria crotonensis.	5	47.059	2.476	204.733	9.194
Fragilaria intermedia	1	0.588	0.037	7.060	0.442
Fragilaria intermedia var. fallax	2	6.987	0.265	77.657	2.861
Fragilaria leptostauron	1	0.294	0.011	3.530	0.130
Fragilaria pinnata var. lancettula.	6	8.825	0.520	56.478	2.520
Fragilaria pinnata.	10	22.578	1.267	105.896	3.901
Gomphonema spp.	1	0.294	0.011	3.530	0.130
Melosira granulata.	1	2.353	0.105	28.239	1.260
Navicula capitata	1	0.294	0.013	3.530	0.157
Navicula cryptocephala var. veneta.	1	0.294	0.013	3.530	0.157
Navicula cryptocephala.	3	0.882	0.070	3.530	0.493
Navicula radiosa var. tenella	1	0.294	0.013	3.530	0.157
Navicula spp.	3	1.765	0.079	10.590	0.472
Nitzschia acicularis.	3	1.177	0.090	7.060	0.476
Nitzschia acuta	1	0.294	0.018	3.530	0.221
Nitzschia angustata var. acuta.	1	0.294	0.018	3.530	0.221
Nitzschia confinis.	1	2.353	0.087	28.239	1.040
Nitzschia dissipata	2	0.882	0.061	7.060	0.442
Nitzschia fonticola	4	3.236	0.260	17.649	1.478
Nitzschia gracilis.	1	0.588	0.082	7.060	0.985
Nitzschia spp..	2	0.882	0.050	7.060	0.315
Stephanodiscus niagarae	1	0.294	0.019	3.530	0.231
Stephanodiscus spp.	1	0.588	0.079	7.060	0.952
Surirella angusta	1	0.294	0.018	3.530	0.221
Synedra acus.	1	0.294	0.011	3.530	0.130
Synedra filiformis.	5	2.353	0.159	14.120	0.924

Tabellaria fenestrata	3	1.765	0.087	10.590	0.472
Tabellaria flocculosa var. linearis	1	0.294	0.024	3.530	0.289
total diatoms (44 categories) . .		629.429	46.721		

name	number slides	average density	& % pop.	maximum density	& % pop.
Chrysococcus dokidophorus	1	1.177	0.043	14.120	0.520
Chrysosphaerella longispina	12	214.886	15.831	398.876	26.567
Dinobryon cyst.	5	2.647	0.154	14.120	0.520
Dinobryon divergens	1	0.588	0.054	7.060	0.645
Dinobryon spp..	2	2.059	0.227	14.120	1.429
Mallomonas spp.	5	2.059	0.127	7.060	0.462
Ochromonas spp.	5	15.454	1.080	61.903	5.911
total chrysophytes (7 categories) . .		238.871	17.515		

name	number slides	average density	& % pop.	maximum density	& % pop.
Cryptomonas erosa	1	1.177	0.074	14.120	0.885
Cryptomonas ovata	8	7.689	0.589	21.666	1.493
Cryptomonas spp..	12	19.821	1.465	38.829	2.434
Rhodomonas minuta	1	0.588	0.038	7.060	0.462
Rhodomonas minuta var. nannoplanctica . . .	12	92.685	6.230	187.083	11.726
total cryptomonads (5 categories) . .		121.960	8.397		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ceratium hirundinella	1	0.294	0.041	3.530	0.493
total dinoflagellates (1 categories) . .		0.294	0.041		

* *

total number of slides: 12 total number of taxa: 77

minimum total density: 716.56 maximum total density: 2714.47

average total density: 1446.85

* *

APPENDIX III. Port Huron-Summer-Tap "SUMMARY"

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  file name        F#
>DNR8008PSINN       1
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name	number slides	average density	average % pop.	maximum density	maximum % pop.
Undetermined flagellate spp.	12	59.356	5.324	134.135	9.155
total undetermined (1 categories)		59.356	5.324		

name	number slides	average density	average % pop.	maximum density	maximum % pop.
Anabaena flos-aquae	1	1.765	0.101	21.179	1.210
Anacystis incerta	3	54.703	4.930	360.047	31.003
Anacystis thermalis	7	12.653	1.064	56.478	5.229
Gomphosphaeria lacustris	6	52.360	3.641	232.972	16.622
Oscillatoria spp.	1	5.001	0.431	60.008	5.167
Undetermined blue-green filament	5	13.825	1.396	67.068	6.690
total blue-green (6 categories)		140.307	11.563		

name	number slides	average density	average % pop.	maximum density	maximum % pop.
Ankistrodesmus spp.	1	0.294	0.029	3.530	0.345
Gloeocystis planctonica	7	61.479	4.966	381.227	20.690
Oocystis spp.	5	4.412	0.420	21.179	1.648
Scenedesmus carinatus	3	3.828	0.380	24.761	2.759
Scenedesmus quadricauda	4	6.766	0.639	28.239	2.414
Scenedesmus spp.	3	5.589	0.587	31.769	4.624
Undetermined green colonies	1	1.177	0.067	14.120	0.806
Undetermined green individual	2	2.942	0.276	28.239	2.759
total green (8 categories)		86.486	7.363		

name	number slides	average density	& % pop.	maximum density	& % pop.
Achnanthes clevei var. rostrata	3	0.882	0.074	3.530	0.355
Achnanthes exigua	2	0.588	0.052	3.530	0.355
Achnanthes spp.	3	0.882	0.062	3.530	0.275
Amphora ovalis var. pediculus	2	0.588	0.039	3.530	0.268
Amphora ovalis.	3	2.353	0.144	14.120	0.766
Amphora perpusilla.	6	4.412	0.322	17.649	1.034
Asterionella formosa.	1	0.258	0.029	3.095	0.345
Caloneis spp.	1	0.294	0.017	3.530	0.202
Cocconeis diminuta.	4	1.765	0.125	10.590	0.605
Cocconeis placentula var. euglypta.	1	0.258	0.029	3.095	0.345
Cyclotella comensis	12	519.572	47.066	833.051	59.669
Cyclotella comta.	6	5.634	0.603	46.427	5.172
Cyclotella meneghiniana	1	0.588	0.046	7.060	0.549
Cyclotella michiganiana	2	0.846	0.062	7.060	0.403
Cyclotella ocellata	12	6.729	0.599	14.120	1.156
Cyclotella operculata	3	1.177	0.105	7.060	0.549
Cyclotella pseudostelligera	2	0.588	0.046	3.530	0.345
Cyclotella spp.	1	4.901	0.546	58.808	6.552
Cyclotella stelligera	11	12.060	1.101	31.769	3.191
Cymbella microcephala	4	1.471	0.107	7.060	0.383
Cymbella minuta	1	0.294	0.023	3.530	0.275
Cymbella minuta fo. latens.	1	0.774	0.086	9.285	1.034
Denticula tenuis var. crassula.	2	0.588	0.056	3.530	0.345
Diploneis oculata	1	0.294	0.017	3.530	0.202
Diploneis parma	1	0.294	0.048	3.530	0.578
Fragilaria capucina	3	15.884	1.428	134.135	13.103
Fragilaria construens	6	11.766	0.869	56.478	4.290
Fragilaria construens var. binodis.	1	0.588	0.046	7.060	0.549
Fragilaria crotonensis.	9	29.827	2.953	81.187	8.840
Fragilaria intermedia var. fallax	2	1.104	0.102	7.060	0.690
Fragilaria leptostauron	5	2.942	0.264	10.590	1.105
Fragilaria pinnata var. lancettula.	9	15.006	1.501	42.359	5.780
Fragilaria pinnata.	12	37.366	3.169	109.426	6.250
Mastogloia spp.	1	0.294	0.048	3.530	0.578
Melosira distans var. alpigena.	1	0.588	0.054	7.060	0.654
Melosira granulata alpha status	2	1.765	0.117	10.590	0.804
Navicula capitata	4	2.611	0.180	17.649	0.958
Navicula cryptocephala var. veneta.	1	0.588	0.045	7.060	0.536
Navicula cryptocephala.	3	0.846	0.104	3.530	0.578
Navicula radiosa var. tenella	4	1.177	0.100	3.530	0.355
Navicula radiosa.	3	0.882	0.106	3.530	0.578
Navicula spp.	7	2.647	0.246	7.060	0.709
Navicula tripunctata.	1	0.774	0.086	9.285	1.034
Nitzschia acicularis.	7	3.715	0.362	10.590	1.034
Nitzschia acuta	1	1.177	0.064	14.120	0.766
Nitzschia dissipata	5	2.059	0.199	7.060	0.578
Nitzschia fonticola	9	5.738	0.501	12.381	1.379
Nitzschia gracilis.	7	2.353	0.241	7.060	0.690
Nitzschia spp..	6	3.494	0.318	14.120	1.099
Nitzschia sublinearis	1	0.258	0.029	3.095	0.345
Rhizosolenia gracilis	1	0.294	0.023	3.530	0.275
Stephanodiscus alpinus.	2	0.882	0.080	7.060	0.608
Stephanodiscus binderanus	1	0.588	0.045	7.060	0.536
Synedra acus.	2	0.882	0.068	7.060	0.536
Synedra filiformis.	6	2.942	0.237	7.060	0.608
Synedra spp..	1	0.294	0.027	3.530	0.327
Tabellaria fenestrata	8	4.706	0.431	10.590	1.156

Tabellaria fenestrata var. geniculata . . .	1	0.294	0.027	3.530	0.327
Tabellaria flocculosa var. linearis	1	0.258	0.029	3.095	0.345
total diatoms (59 categories) . .		724.680	65.499		

name	number slides	average density	& % pop.	maximum density	& % pop.
Chrysococcus dokidophorus	1	0.588	0.045	7.060	0.536
Chrysosphaerella longispina	10	50.595	3.949	123.546	8.511
Dinobryon cyst.	6	2.353	0.272	7.060	1.156
Dinobryon divergens	1	0.294	0.029	3.530	0.345
Mallomonas spp.	3	0.882	0.106	3.530	0.578
Monochrysis aphanaster.	1	0.294	0.016	3.530	0.192
Ochromonas spp.	10	11.105	1.158	28.239	4.420
total chrysophytes (7 categories) . .		66.113	5.575		

name	number slides	average density	& % pop.	maximum density	& % pop.
Cryptomonas ovata	10	5.811	0.554	17.649	1.773
Cryptomonas spp..	12	18.459	1.574	38.829	3.169
Rhodomonas minuta	1	0.294	0.016	3.530	0.192
Rhodomonas minuta var. nannoplanctica . . .	11	31.366	2.445	84.717	4.598
total cryptomonads (4 categories) . .		55.930	4.589		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ceratium hirundinella	1	0.294	0.017	3.530	0.202
total dinoflagellates (1 categories) . .		0.294	0.017		

name	number slides	average density	average % pop.	maximum density	maximum % pop.
Euglena spp.	1	0.294	0.023	3.530	0.275
Phacus spp.	1	0.294	0.048	3.530	0.578
total euglenoids (2 categories) . .		0.588	0.071		

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total number of slides: 12 total number of taxa: 88

minimum total density: 610.67 maximum total density: 1842.59

average total density: 1133.76

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APPENDIX III. Port Huron-Spring-Lake "SUMMARY"

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  file name        F#
>DNR8111PPOUT       1
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name	number slides	average density	& % pop.	maximum density	& % pop.
Undetermined flagellate spp.	6	174.114	8.244	575.370	26.164
total undetermined (1 categories) . .		174.114	8.244		

name	number slides	average density	& % pop.	maximum density	& % pop.
Oscillatoria bornetii	2	36.475	1.682	158.844	7.365
Oscillatoria spp.	1	31.181	1.349	187.083	8.092
total blue-green (2 categories) . .		67.656	3.031		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ankistrodesmus spp.	4	4.693	0.250	10.590	0.536
Gloeocystis planctonica	4	29.729	1.789	104.720	5.964
Oocystis spp.	1	0.582	0.045	3.491	0.268
Scenedesmus bicellularis.	1	1.177	0.062	7.060	0.374
Scenedesmus bijuga.	1	2.327	0.179	13.963	1.072
Scenedesmus quadricauda	5	11.165	0.529	21.179	0.916
Scenedesmus spp..	3	8.210	0.426	21.179	1.121
Ulothrix spp.	1	1.765	0.080	10.590	0.482
total green (8 categories) . .		59.648	3.360		

name	number slides	average density	% pop.	maximum density	% pop.
Achnanthes spp.	1	1.164	0.066	6.981	0.398
Actinocyclus normanii f. subsalsa	1	0.588	0.025	3.530	0.153
Amphora perpusilla.	3	2.922	0.164	7.060	0.398
Asterionella formosa.	6	52.752	2.838	81.187	4.299
Cocconeis diminuta.	1	0.588	0.025	3.530	0.153
Cocconeis placentula var. euglypta.	1	0.582	0.033	3.491	0.199
Cyclotella comensis	6	34.593	1.813	70.598	3.210
Cyclotella comta.	2	1.170	0.064	3.530	0.199
Cyclotella meneghiniana	2	2.909	0.212	13.963	1.072
Cyclotella ocellata	6	33.939	1.916	49.418	3.753
Cyclotella pseudostelligera	2	2.347	0.125	10.590	0.482
Cyclotella stelligera	5	15.786	0.888	38.397	2.187
Cymbella microcephala	3	1.758	0.085	3.530	0.199
Cymbella minuta	1	1.164	0.089	6.981	0.536
Cymbella spp.	1	0.582	0.033	3.491	0.199
Diatoma tenue var. elongatum.	1	1.177	0.055	7.060	0.327
Fragilaria capucina	6	750.098	38.942	1027.194	46.916
Fragilaria construens	4	21.683	1.198	56.478	2.949
Fragilaria crotonensis.	4	44.398	2.666	104.720	8.043
Fragilaria intermedia	1	0.588	0.031	3.530	0.187
Fragilaria pinnata var. lancettula.	2	2.942	0.135	14.120	0.655
Fragilaria pinnata.	6	42.731	2.443	80.285	6.166
Gomphonema spp.	1	0.582	0.045	3.491	0.268
Melosira distans var. alpigena.	1	3.491	0.268	20.944	1.609
Melosira granulata.	2	5.256	0.279	20.944	1.193
Melosira islandica.	5	20.539	1.050	52.948	2.455
Navicula capitata	1	0.582	0.033	3.491	0.199
Navicula radiosa.	1	1.745	0.134	10.472	0.804
Navicula spp.	5	3.510	0.194	6.981	0.398
Nitzschia acicularis.	3	4.687	0.246	10.590	0.596
Nitzschia confinis.	1	1.177	0.051	7.060	0.305
Nitzschia dissipata	2	1.170	0.060	3.530	0.199
Nitzschia fonticola	5	4.693	0.233	7.060	0.398
Nitzschia gracilis.	5	7.622	0.433	13.963	1.072
Nitzschia spp..	5	5.864	0.289	10.590	0.596
Rhizosolenia gracilis	6	28.762	1.438	81.187	3.692
Surirella spp..	2	1.177	0.057	3.530	0.187
Synedra acus.	6	19.369	1.017	45.888	2.128
Synedra cyclopum.	1	0.588	0.027	3.530	0.164
Synedra filiformis.	6	52.700	2.838	90.757	5.169
Synedra parasitica.	1	1.164	0.089	6.981	0.536
Synedra spp..	1	3.530	0.161	21.179	0.963
Synedra ulna var. danica.	3	1.758	0.086	3.530	0.199
Synedra ulna.	3	3.510	0.215	10.472	0.804
Tabellaria fenestrata	6	106.779	5.476	141.195	6.547
Tabellaria flocculosa	1	5.236	0.402	31.416	2.413
Tabellaria flocculosa var. linearis	2	9.308	0.553	48.869	2.783
total diatoms (47 categories)		1311.252	69.522		

name	number slides	average density	& % pop.	maximum density	& % pop.
Chrysococcus dokidophorus	2	1.177	0.057	3.530	0.187
Dinobryon cyst.	4	11.688	0.666	27.925	1.590
Dinobryon divergens	3	36.240	1.970	91.777	5.169
Dinobryon spp..	4	170.022	7.921	455.354	21.113
Ochromonas spp.	1	2.942	0.134	17.649	0.803
total chrysophytes (5 categories) . .		222.068	10.747		

name	number slides	average density	& % pop.	maximum density	& % pop.
Cryptomonas ovata	6	17.623	0.897	35.299	1.869
Cryptomonas spp..	5	8.818	0.420	17.649	0.818
Rhodomonas minuta	5	34.044	1.717	88.247	4.092
Rhodomonas minuta var. nannoplanctica . . .	6	40.476	2.062	63.538	2.889
total cryptomonads (4 categories) . .		100.961	5.096		

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total number of slides: 6 total number of taxa: 67

minimum total density: 1302.01 maximum total density: 2312.07

average total density: 1935.70

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APPENDIX III. Port Huron-Spring-Tap "SUMMARY"

file name	F#
>DNR8112PPINN	1
>	

name	number slides	average density	& % pop.	maximum density	& % pop.
Undetermined flagellate spp.	6	151.700	6.680	607.138	25.943
total undetermined (1 categories) . .		151.700	6.680		

name	number slides	average density	& % pop.	maximum density	& % pop.
Gomphosphaeria lacustris.	2	55.301	1.956	289.450	9.382
Oscillatoria bornetii	1	15.296	0.654	91.777	3.922
Oscillatoria spp.	1	7.563	0.476	45.379	2.857
total blue-green (3 categories) . .		78.161	3.086		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ankistrodesmus spp.	4	7.021	0.367	20.944	1.319
Cosmarium spp..	3	1.758	0.139	3.530	0.463
Crucigenia spp.	1	9.413	0.402	56.478	2.413
Gloeocystis planctonica	3	22.794	1.253	80.285	5.055
Oocystis spp.	3	13.531	0.635	49.418	2.456
Scenedesmus quadricauda	4	12.891	0.654	28.239	1.758
Scenedesmus spp..	6	39.979	1.879	84.717	3.620
Tetraedron minimum.	2	1.177	0.062	3.530	0.196
Ulothrix spp.	1	24.709	1.373	148.255	8.235
total green (9 categories) . .		133.272	6.763		

name	number slides	average density	average % pop.	maximum density	maximum % pop.
Achnanthes biasolettiana.	1	0.582	0.037	3.491	0.220
Achnanthes exigua	1	0.582	0.037	3.491	0.220
Amphora ovalis.	1	0.588	0.019	3.530	0.114
Amphora perpusilla.	5	8.223	0.372	21.179	0.905
Amphora spp..	1	0.588	0.019	3.530	0.114
Asterionella formosa.	6	27.579	1.496	42.359	2.353
Cyclotella comensis	6	56.929	2.756	172.964	5.606
Cyclotella comta.	2	3.504	0.205	13.963	0.879
Cyclotella kutzingiana.	1	0.588	0.019	3.530	0.114
Cyclotella meneghiniana	2	6.400	0.525	27.925	1.758
Cyclotella ocellata	6	43.940	2.789	60.008	6.481
Cyclotella stelligera	5	25.703	1.730	73.304	4.615
Cymatopleura solea.	1	0.582	0.077	3.491	0.463
Cymbella minuta	2	1.164	0.114	3.491	0.463
Diatoma tenue var. elongatum.	1	0.588	0.019	3.530	0.114
Entomoneis ornata	1	0.588	0.025	3.530	0.151
Fragilaria capucina	6	736.077	36.342	1383.711	52.105
Fragilaria construens	4	11.766	0.525	21.179	0.980
Fragilaria crotonensis.	6	76.141	4.758	155.315	9.722
Fragilaria intermedia var. fallax	2	6.471	0.319	28.239	1.569
Fragilaria leptostauron	1	4.118	0.133	24.709	0.801
Fragilaria pinnata var. lancettula.	5	17.630	0.766	52.948	1.716
Fragilaria pinnata.	6	46.339	2.195	127.076	4.119
Gomphonema spp.	1	0.588	0.029	3.530	0.175
Melosira distans var. alpigena.	2	2.353	0.103	7.060	0.392
Melosira granulata.	1	1.745	0.231	10.472	1.389
Melosira islandica.	5	29.971	1.434	56.478	3.137
Navicula spp.	5	5.850	0.480	13.963	1.852
Nitzschia acicularis.	5	11.727	0.596	20.944	1.319
Nitzschia confinis.	1	0.588	0.025	3.530	0.151
Nitzschia dissipata	4	2.347	0.164	3.530	0.463
Nitzschia fonticola	5	5.850	0.339	13.963	0.879
Nitzschia gracilis.	6	8.779	0.581	13.963	1.389
Nitzschia spp..	4	10.511	0.909	27.925	3.704
Nitzschia sublinearis	1	0.588	0.025	3.530	0.151
Rhizosolenia gracilis	6	19.369	0.992	52.948	1.716
Stephanodiscus alpinus.	1	0.582	0.077	3.491	0.463
Stephanodiscus niagarae	1	0.582	0.077	3.491	0.463
Synedra acus.	6	16.401	1.055	21.179	2.315
Synedra cyclopum.	1	0.582	0.037	3.491	0.220
Synedra filiformis.	6	67.421	3.978	98.837	7.870
Synedra parasitica.	1	0.588	0.025	3.530	0.151
Synedra spp..	1	2.353	0.101	14.120	0.603
Synedra ulna var. danica.	3	4.105	0.179	14.120	0.458
Synedra ulna.	4	5.877	0.307	14.120	0.526
Tabellaria fenestrata	6	69.872	3.647	105.896	5.882
Tabellaria flocculosa	5	12.315	0.597	20.944	1.319
Tabellaria flocculosa var. linearis	3	32.063	2.103	143.117	9.011
total diatoms (48 categories) . .		1389.674	73.367		

name	number slides	average density	& % pop.	maximum density	& % pop.
Chrysococcus dokidophorus	1	0.588	0.019	3.530	0.114
Dinobryon cyst.	5	9.354	0.700	17.453	2.315
Dinobryon divergens	4	81.507	5.127	197.673	10.980
Dinobryon spp..	4	48.830	1.985	137.665	4.462
Mallomonas spp.	1	0.588	0.033	3.530	0.196
Ochromonas spp.	1	1.177	0.038	7.060	0.229
total chrysophytes (6 categories) . .		142.045	7.903		

name	number slides	average density	& % pop.	maximum density	& % pop.
Cryptomonas ovata	5	10.563	0.606	17.649	1.389
Cryptomonas spp..	2	1.177	0.054	3.530	0.175
Rhodomonas minuta	3	4.079	0.371	10.472	1.389
Rhodomonas minuta var. nannoplanctica . . .	5	19.310	1.170	38.397	2.418
total cryptomonads (4 categories) . .		35.129	2.201		

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total number of slides: 6 total number of taxa: 71
minimum total density: 753.98 maximum total density: 3085.11
average total density: 1929.98

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APPENDIX III. Alpena-Summer-Lake "SUMMARY"

file name	F#
>DNR8001ASOUT	1
>	

name	number slides	average density	& % pop.	maximum density	& % pop.
Undetermined flagellate spp..	10	38.840	0.504	215.322	2.367
total undetermined (1 categories) . .		38.840	0.504		

name	number slides	average density	& % pop.	maximum density	& % pop.
Anabaena flos-aquae	1	11.345	0.201	136.136	2.409
Anacystis incerta	1	19.414	0.238	232.972	2.853
Anacystis spp..	1	3.236	0.040	38.829	0.476
Anacystis thermalis	9	31.785	0.520	105.896	2.364
Gomphosphaeria lacustris.	4	29.863	0.385	150.098	2.202
total blue-green (5 categories) . .		95.643	1.383		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ankistrodesmus spp.	3	0.846	0.012	3.530	0.065
Cosmarium spp..	2	0.588	0.007	3.530	0.048
Crucigenia quadrata	3	9.916	0.190	55.850	1.027
Gloeocystis planctonica	8	77.598	1.013	240.032	2.946
Oocystis spp.	4	4.693	0.063	21.179	0.288
Pediastrum boryanum	2	7.896	0.114	48.869	0.865
Pediastrum spp.	1	0.291	0.009	3.491	0.103
Pediastrum tetras	1	1.177	0.013	14.120	0.155
Quadrigula spp.	1	0.588	0.006	7.060	0.078
Scenedesmus bicellularis.	3	1.752	0.029	7.060	0.158
Scenedesmus bijuga.	4	7.881	0.150	41.888	0.680
Scenedesmus quadricauda	7	13.466	0.212	35.299	0.821

Scenedesmus serratus.	1	1.164	0.017	13.963	0.205
Scenedesmus spinosus.	2	2.059	0.024	14.120	0.155
Scenedesmus spp..	10	46.450	0.762	91.777	1.891
Ulothrix zonata	1	1.177	0.016	14.120	0.192
Undetermined green colonies	1	4.707	0.058	56.478	0.692
Undetermined green individual	3	4.099	0.053	20.944	0.307
total green (18 categories) . .		186.349	2.747		

name	number slides	average density	& % pop.	maximum density	& % pop.
Achnanthes clevei var. rostrata	10	3.177	0.057	6.981	0.124
Achnanthes exigua	12	8.409	0.135	21.179	0.233
Achnanthes lanceolata var. dubia.	1	0.291	0.007	3.491	0.079
Achnanthes lanceolata var. omissa	2	0.882	0.012	7.060	0.096
Achnanthes spp.	9	17.100	0.297	48.869	0.865
Amphora ovalis var. affinis	5	2.625	0.053	10.472	0.308
Amphora ovalis var. pediculus	4	1.689	0.026	7.060	0.130
Amphora ovalis.	11	11.034	0.186	21.179	0.411
Amphora perpusilla.	11	24.907	0.403	59.341	0.780
Amphora thumensis	2	0.873	0.015	6.981	0.124
Asterionella formosa.	12	35.180	0.592	73.304	1.132
Cocconeis diminuta.	5	3.781	0.049	14.120	0.155
Cocconeis placentula var. euglypta.	5	2.879	0.047	13.963	0.227
Cyclotella comensis	12	4601.148	71.512	6611.457	82.954
Cyclotella comta.	12	26.292	0.422	48.869	0.642
Cyclotella meneghiniana	1	0.294	0.003	3.530	0.039
Cyclotella michiganiana	10	30.703	0.519	63.538	1.051
Cyclotella ocellata	8	9.037	0.179	27.925	0.630
Cyclotella operculata	3	3.236	0.040	17.649	0.217
Cyclotella pseudostelligera	10	10.197	0.201	27.925	0.647
Cyclotella spp.	2	1.765	0.022	14.120	0.173
Cyclotella stelligera	12	235.114	3.685	335.338	4.415
Cymatopleura solea.	2	0.582	0.011	3.491	0.081
Cymbella microcephala	11	13.459	0.203	24.709	0.371
Cymbella minuta	7	3.494	0.056	20.944	0.275
Cymbella minuta fo. latens.	1	0.294	0.004	3.530	0.043
Cymbella spp.	4	1.458	0.022	6.981	0.113
Denticula tenuis var. crassula.	3	1.464	0.024	7.060	0.158
Diploneis oculata	1	0.582	0.013	6.981	0.162
Fragilaria brevistriata	2	7.552	0.140	55.713	1.171
Fragilaria capucina	9	14.346	0.222	28.239	0.520
Fragilaria construens	9	23.668	0.469	80.285	1.745
Fragilaria crotonensis.	12	366.716	6.788	823.794	19.078
Fragilaria intermedia	2	2.353	0.031	21.179	0.288
Fragilaria intermedia var. fallax	5	9.952	0.147	52.948	0.720
Fragilaria leptostauron	4	1.758	0.028	7.060	0.158
Fragilaria pinnata var. lancettula.	12	73.397	1.243	141.195	2.156
Fragilaria pinnata.	12	109.314	1.863	178.023	5.236
Fragilaria spp.	4	1.464	0.024	7.060	0.103
Gomphonema spp.	2	0.876	0.013	6.981	0.113
Melosira granulata alpha status	3	36.090	0.469	172.964	2.354
Melosira granulata var. angustissima. . . .	1	0.582	0.009	6.981	0.113

Melosira granulata.	9	105.817	1.920	293.215	5.188
Navicula capitata	10	6.389	0.109	17.453	0.309
Navicula capitata var. luneburgensis. . . .	1	0.294	0.004	3.530	0.043
Navicula cryptocephala var. veneta.	6	3.190	0.051	14.120	0.162
Navicula cryptocephala.	3	0.843	0.014	3.530	0.065
Navicula pupula	4	1.164	0.021	3.491	0.079
Navicula radiosa var. tenella	10	4.601	0.082	10.590	0.162
Navicula radiosa.	3	0.879	0.011	3.530	0.048
Navicula scutelloides	1	0.291	0.005	3.491	0.057
Navicula spp.	10	12.822	0.244	27.925	0.719
Neidium dubium fo. constrictum.	1	0.291	0.009	3.491	0.103
Nitzschia acicularis.	8	3.219	0.051	14.120	0.173
Nitzschia acuta	1	0.588	0.007	7.060	0.087
Nitzschia angustata var. acuta.	1	0.291	0.004	3.491	0.046
Nitzschia confinis.	4	1.468	0.021	7.060	0.081
Nitzschia dissipata	7	5.203	0.090	20.944	0.371
Nitzschia fonticola	12	16.092	0.270	52.360	0.768
Nitzschia gracilis.	5	3.203	0.071	13.963	0.411
Nitzschia sigmoidea	1	0.582	0.010	6.981	0.124
Nitzschia spp..	12	14.766	0.249	34.907	0.512
Rhizosolenia eriensis	7	2.634	0.039	7.060	0.096
Rhizosolenia gracilis	3	1.762	0.021	10.590	0.116
Rhizosolenia statospore	4	2.059	0.025	10.590	0.130
Stephanodiscus alpinus.	1	0.291	0.005	3.491	0.062
Surirella spp..	1	0.294	0.004	3.530	0.043
Synedra acus.	9	7.517	0.112	27.925	0.367
Synedra filiformis.	4	1.464	0.021	7.060	0.096
Synedra parasitica.	2	0.879	0.013	7.060	0.081
Synedra spp..	3	1.468	0.019	10.590	0.130
Synedra ulna.	3	1.758	0.025	14.120	0.155
Tabellaria fenestrata	12	33.084	0.596	69.813	2.053
Tabellaria flocculosa	2	0.876	0.017	6.981	0.162
Tabellaria flocculosa var. linearis	8	8.647	0.158	21.179	0.513
total diatoms (75 categories) . .		5944.609	94.535		

name	number slides	average density	& % pop.	maximum density	& % pop.
Chrysococcus dokidophorus	1	0.291	0.004	3.491	0.046
Dinobryon cyst.	8	5.262	0.081	20.944	0.275
Dinobryon divergens	5	9.063	0.116	49.418	0.597
Dinobryon spp..	2	2.647	0.030	21.179	0.233
Mallomonas statospore	1	0.588	0.007	7.060	0.086
Monochrysis aphanaster.	1	0.294	0.004	3.530	0.043
Ochromonas spp.	8	15.247	0.184	120.016	1.319
total chrysophytes (7 categories) . .		33.393	0.426		

name	number slides	average density	& % pop.	maximum density	& % pop.
Cryptomonas erosa	1	0.582	0.013	6.981	0.162
Cryptomonas ovata	10	13.850	0.242	42.359	0.808
Cryptomonas spp..	8	4.399	0.057	14.120	0.173
Rhodomonas minuta var. nannoplanctica . . .	4	6.462	0.077	49.418	0.543
total cryptomonads (4 categories) . .		25.293	0.388		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ceratium hirundinella	1	0.291	0.007	3.491	0.081
Gymnodinium spp..	1	0.258	0.005	3.095	0.065
total dinoflagellates (2 categories) . .		0.549	0.012		

name	number slides	average density	& % pop.	maximum density	& % pop.
Trachelomonas spp..	1	0.294	0.004	3.530	0.048
total euglenoids (1 categories) . .		0.294	0.004		

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total number of slides: 12 total number of taxa: 113

minimum total density: 3399.90 maximum total density: 9096.49

average total density: 6325.09

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APPENDIX III. Alpena-Summer-Tap "SUMMARY"

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  file name        F#
>DNR8002ASINN       1
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name	number slides	average density	& % pop.	maximum density	& % pop.
Undetermined flagellate spp..	8	17.641	0.245	74.127	0.921
total undetermined (1 categories) . .		17.641	0.245		

name	number slides	average density	& % pop.	maximum density	& % pop.
Anabaena flos-aquae	2	3.200	0.055	24.435	0.348
Anacystis incerta	4	84.599	1.028	596.549	7.409
Anacystis thermalis	8	28.771	0.488	164.061	3.030
Gomphosphaeria lacustris.	1	7.060	0.088	84.717	1.052
Undetermined blue-green filament.	2	8.825	0.106	91.777	1.004
total blue-green (5 categories) . .		132.454	1.765		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ankistrodesmus spp.	1	1.177	0.014	14.120	0.166
Botryococcus braunii.	1	10.575	0.163	126.902	1.959
Cosmarium spp..	1	0.294	0.003	3.530	0.042
Crucigenia quadrata	1	7.060	0.077	84.717	0.927
Gloeocystis planctonica	11	23.346	0.317	66.322	0.854
Oocystis spp.	4	5.984	0.084	40.237	0.621
Pediastrum boryanum	2	9.034	0.238	90.757	2.632
Pediastrum duplex	1	5.527	0.070	66.322	0.843
Pediastrum integrum	1	4.363	0.056	52.360	0.674
Pediastrum spp.	3	16.669	0.227	95.307	1.042
Scenedesmus bicellularis.	2	1.164	0.015	6.981	0.089
Scenedesmus bijuga.	5	20.983	0.245	83.776	1.065

Scenedesmus carinatus	2	2.340	0.028	14.120	0.178
Scenedesmus quadricauda	7	14.054	0.191	56.478	0.664
Scenedesmus serratus.	6	10.248	0.158	28.239	0.696
Scenedesmus spinosus.	2	2.208	0.030	14.120	0.191
Scenedesmus spp..	12	56.267	0.917	97.738	2.435
Undetermined green individual	3	7.910	0.100	49.418	0..581
total green (18 categories) . .		199.203	2.934		

name	number slides	average density	& % pop.	maximum density	& % pop.
Achnanthes clevei var. rostrata	9	7.533	0.110	24.435	0.238
Achnanthes exigua	11	9.203	0.130	17.453	0.322
Achnanthes lanceolata var. dubia.	3	1.164	0.018	6.981	0.089
Achnanthes lanceolata var. omissa	4	1.392	0.018	6.190	0.096
Achnanthes spp.	7	17.162	0.255	55.850	1.032
Amphora ovalis var. affinis	4	1.752	0.029	7.060	0.101
Amphora ovalis var. pediculus	4	1.428	0.020	6.981	0.087
Amphora ovalis.	10	11.953	0.189	41.888	0.539
Amphora perpusilla.	12	27.112	0.440	59.341	1.043
Amphora spp..	1	0.294	0.003	3.530	0.042
Amphora thumensis	3	0.873	0.013	3.491	0.064
Asterionella formosa.	11	35.389	0.585	104.720	1.619
Cocconeis diminuta.	7	5.206	0.071	14.120	0.202
Cocconeis placentula var. euglypta.	8	4.301	0.059	13.963	0.136
Cyclotella antiqua.	1	0.291	0.004	3.491	0.044
Cyclotella comensis	12	4537.008	63.475	7553.773	75.322
Cyclotella comta.	12	36.179	0.564	60.008	1.113
Cyclotella meneghiniana	3	2.049	0.024	10.590	0.135
Cyclotella michiganiana	12	34.245	0.524	59.341	0.911
Cyclotella ocellata	11	17.450	0.243	76.794	0.747
Cyclotella operculata	3	1.468	0.016	10.590	0.125
Cyclotella pseudostelligera	9	9.157	0.169	20.944	0.607
Cyclotella spp.	2	15.716	0.212	98.837	1.386
Cyclotella stelligera	12	157.158	2.181	310.629	3.653
Cymatopleura solea.	3	0.876	0.017	3.530	0.101
Cymbella cistula.	1	0.588	0.007	7.060	0.083
Cymbella microcephala	10	9.831	0.139	24.709	0.291
Cymbella minuta	5	2.552	0.048	6.981	0.202
Cymbella minuta fo. latens.	1	0.294	0.003	3.530	0.042
Cymbella spp.	4	2.327	0.039	13.963	0.202
Denticula spp..	1	0.291	0.003	3.491	0.034
Denticula tenuis var. crassula.	5	2.879	0.042	17.453	0.225
Diatoma tenue var. elongatum.	4	1.173	0.016	3.530	0.067
Fragilaria brevistriata	5	17.576	0.200	97.738	0.951
Fragilaria capucina	12	66.552	0.906	197.673	2.307
Fragilaria construens	10	96.022	1.192	705.975	8.768
Fragilaria construens var. binodis.	1	0.291	0.003	3.491	0.034
Fragilaria crotonensis.	11	598.819	9.184	1155.407	14.410
Fragilaria intermedia	1	1.471	0.017	17.649	0.208
Fragilaria intermedia var. fallax	7	34.400	0.464	198.967	2.481
Fragilaria leptostauron	8	5.530	0.069	17.649	0.208
Fragilaria pinnata var. lancettula.	12	159.378	2.303	272.271	3.868

Fragilaria pinnata.	12	212.591	3.060	338.594	4.360
Fragilaria vaucheriae	1	0.291	0.003	3.491	0.034
Melosira granulata alpha status	2	20.301	0.246	218.852	2.574
Melosira granulata var. angustissima. . . .	1	2.059	0.024	24.709	0.291
Melosira granulata.	12	263.671	4.300	614.355	8.522
Navicula capitata	9	9.329	0.139	27.856	0.430
Navicula capitata var. luneburgensis. . . .	1	0.774	0.012	9.285	0.143
Navicula cryptocephala var. veneta.	2	0.879	0.015	7.060	0.101
Navicula cryptocephala.	4	2.562	0.033	10.590	0.125
Navicula pupula	1	0.588	0.007	7.060	0.083
Navicula radiosa var. tenella	6	3.500	0.042	17.453	0.170
Navicula radiosa.	2	0.582	0.009	3.491	0.064
Navicula spp.	11	22.163	0.315	48.869	0.621
Navicula stroesei	1	0.294	0.003	3.530	0.042
Nitzschia acicularis.	7	6.205	0.080	28.239	0.334
Nitzschia acuta	5	2.925	0.036	14.120	0.175
Nitzschia angustata var. acuta.	2	0.552	0.007	3.530	0.048
Nitzschia confinis.	5	4.350	0.061	21.179	0.270
Nitzschia denticula	1	0.291	0.005	3.491	0.064
Nitzschia dissipata	9	7.302	0.104	21.179	0.249
Nitzschia fonticola	12	23.541	0.335	41.888	0.539
Nitzschia gracilis.	7	6.132	0.116	20.944	0.522
Nitzschia sigmoidea	1	0.291	0.007	3.491	0.087
Nitzschia spp..	11	17.212	0.266	31.416	0.609
Rhizosolenia eriensis	1	0.258	0.004	3.095	0.048
Rhizosolenia gracilis	1	0.294	0.003	3.530	0.042
Rhizosolenia statospore	3	1.987	0.024	14.120	0.154
Stephanodiscus alpinus.	2	0.585	0.009	3.530	0.064
Stephanodiscus binderanus	2	2.059	0.024	14.120	0.154
Stephanodiscus niagarae	3	0.876	0.012	3.530	0.064
Synedra acus.	11	6.998	0.106	13.963	0.258
Synedra filiformis.	9	7.398	0.113	18.571	0.287
Synedra parasitica.	4	1.461	0.024	7.060	0.101
Synedra spp..	1	0.294	0.003	3.530	0.042
Synedra ulna var. danica.	1	0.588	0.007	7.060	0.083
Synedra ulna.	7	3.510	0.062	7.060	0.174
Tabellaria fenestrata	12	43.490	0.640	95.307	1.043
Tabellaria flocculosa	5	3.216	0.049	10.590	0.135
Tabellaria flocculosa var. linearis	9	10.479	0.159	27.925	0.430
total diatoms (81 categories) . .		6628.094	94.472		

name	number slides	average density	& % pop.	maximum density	& % pop.
Chrysococcus dokidophorus	1	0.294	0.006	3.530	0.067
Chrysococcus rufescens.	1	0.258	0.004	3.095	0.048
Dinobryon cyst.	10	10.178	0.168	17.649	0.405
Dinobryon divergens	4	4.700	0.056	45.888	0.502
Dinobryon spp..	2	2.059	0.023	21.179	0.232
Mallomonas statospore	1	0.294	0.004	3.530	0.044
Ochromonas spp.	4	2.641	0.035	14.120	0.154
total chrysophytes (7 categories) . .		20.424	0.295		

name	number slides	average density	average % pop.	maximum density	maximum % pop.
Cryptomonas ovata	12	12.588	0.189	28.239	0.539
Cryptomonas spp..	6	5.183	0.066	24.709	0.270
Rhodomonas minuta var. nannoplanctica . . .	2	2.647	0.030	21.179	0.232
total cryptomonads (3 categories) . .		20.418	0.285		

name	number slides	average density	average % pop.	maximum density	maximum % pop.
Ceratium hirundinella	1	0.291	0.003	3.491	0.034
total dinoflagellates (1 categories) . .		0.291	0.003		

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total number of slides: 12 total number of taxa: 116

minimum total density: 3448.77 maximum total density: 10279.98

average total density: 7018.63

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APPENDIX III. Alpena-Fall-Lake "SUMMARY"

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  file name        F#
>DNR8003AFOUT       1
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name	number slides	average density	& % pop.	maximum density	& % pop.
Undetermined flagellate spp..	11	74.693	1.064	264.740	3.193
total undetermined (1 categories) . .		74.693	1.064		

name	number slides	average density	& % pop.	maximum density	& % pop.
Anabaena flos-aquae	1	5.236	0.141	62.832	1.689
Anabaena spp.	2	24.144	0.576	178.023	4.450
Anacystis incerta	9	891.871	13.408	3720.489	33.498
Anacystis thermalis	7	19.697	0.559	71.189	2.293
Gomphosphaeria lacustris.	10	795.529	15.532	1644.922	35.166
Oscillatoria bornetii	2	41.044	0.937	263.089	8.475
Oscillatoria spp.	2	25.016	0.775	212.930	7.020
total blue-green (7 categories) . .		1802.537	31.927		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ankistrodesmus spp.	2	0.876	0.018	6.981	0.175
Chlamydomonas spp..	1	0.291	0.011	3.491	0.137
Cosmarium spp..	1	0.258	0.008	3.095	0.100
Crucigenia quadrata	1	3.491	0.094	41.888	1.126
Gloeocystis planctonica	9	80.481	1.485	264.740	3.285
Lagerheimia spp..	1	0.291	0.006	3.491	0.077
Mougeotia sp. #1.	1	0.258	0.008	3.095	0.100
Oocystis spp.	3	5.222	0.081	35.299	0.426
Pediastrum boryanum	1	7.354	0.089	88.247	1.064
Pediastrum duplex	2	14.835	0.382	104.720	2.618
Scenedesmus bicellularis.	1	0.588	0.007	7.060	0.085
Scenedesmus bijuga.	2	2.327	0.056	13.963	0.365

Scenedesmus quadricauda	4	7.047	0.088	42.359	0.372
Scenedesmus serratus.	4	7.745	0.179	27.925	0.750
Scenedesmus spinosus.	2	1.765	0.019	14.120	0.170
Scenedesmus spp..	8	18.590	0.390	56.478	1.393
Spondylosium planum	1	2.327	0.077	27.925	0.921
Tetraedron minimum.	1	1.164	0.031	13.963	0.375
Ulothrix spp.	1	1.454	0.039	17.453	0.469
Undetermined green colonies	1	3.611	0.116	43.332	1.396
Undetermined green individual	1	0.588	0.005	7.060	0.062
total green (21 categories) . .		160.563	3.191		

name	number slides	average density	& % pop.	maximum density	& % pop.
Achnanthes biasolettiana.	3	2.621	0.091	24.435	0.975
Achnanthes clevei var. rostrata	6	3.683	0.104	10.472	0.345
Achnanthes exigua	6	2.925	0.056	7.060	0.230
Achnanthes lanceolata var. omissa	2	0.588	0.007	3.530	0.043
Achnanthes spp.	6	8.436	0.239	27.925	0.687
Amphora ovalis var. affinis	3	1.908	0.052	12.381	0.399
Amphora ovalis var. pediculus	1	0.294	0.003	3.530	0.038
Amphora ovalis.	7	3.804	0.075	10.590	0.188
Amphora perpusilla.	12	22.563	0.496	45.888	0.824
Amphora spp..	2	2.100	0.061	21.666	0.698
Amphora thumensis	2	1.177	0.011	10.590	0.093
Asterionella formosa.	12	63.202	1.527	165.904	2.532
Cocconeis diminuta.	4	2.634	0.052	10.590	0.345
Cocconeis placentula var. euglypta.	3	1.617	0.045	12.381	0.399
Cyclotella comensis	12	1263.059	28.230	2534.451	49.595
Cyclotella comta.	12	17.811	0.501	38.397	1.459
Cyclotella kutzingiana.	2	0.879	0.013	7.060	0.091
Cyclotella meneghiniana	2	1.323	0.061	12.381	0.648
Cyclotella michiganiana	8	12.053	0.396	43.332	1.396
Cyclotella ocellata	9	12.812	0.239	38.829	0.549
Cyclotella operculata	1	0.291	0.011	3.491	0.137
Cyclotella pseudostelligera	6	6.690	0.214	17.453	0.687
Cyclotella spp.	1	16.508	0.532	198.090	6.381
Cyclotella stelligera	10	25.644	0.670	52.360	1.726
Cymatopleura solea.	2	0.873	0.033	6.981	0.279
Cymbella microcephala	8	7.285	0.184	24.435	0.549
Cymbella minuta	3	1.140	0.022	7.060	0.162
Denticula tenuis var. crassula.	5	2.638	0.045	10.590	0.230
Fragilaria brevistriata	1	1.290	0.042	15.476	0.499
Fragilaria capucina	6	13.757	0.531	55.713	2.917
Fragilaria construens	7	14.809	0.323	49.418	1.196
Fragilaria construens var. binodis.	1	0.291	0.012	3.491	0.139
Fragilaria crotonensis.	12	274.578	6.904	808.341	25.446
Fragilaria intermedia var. fallax	4	10.789	0.204	63.538	0.912
Fragilaria leptostauron	2	1.987	0.030	17.649	0.199
Fragilaria leptostauron var. dubia.	1	0.516	0.017	6.190	0.199
Fragilaria pinnata var. lancettula.	12	143.561	3.048	367.107	7.976
Fragilaria pinnata.	12	258.389	5.262	638.907	9.568
Fragilaria spinosa.	1	8.531	0.103	102.366	1.235
Fragilaria spp.	1	0.873	0.023	10.472	0.281
Gomphonema olivaceum.	1	0.258	0.014	3.095	0.162
Melosira granulata var. angustissima. . . .	1	0.873	0.023	10.472	0.281

Melosira granulata.	12	124.098	3.252	198.967	7.939
Melosira islandica.	4	4.628	0.089	31.769	0.342
Navicula capitata	7	3.336	0.089	12.381	0.399
Navicula capitata var. luneburgensis. . . .	1	0.258	0.008	3.095	0.100
Navicula cryptocephala var. veneta.	6	3.491	0.106	13.963	0.460
Navicula cryptocephala.	3	1.435	0.021	7.060	0.100
Navicula pupula	3	0.846	0.019	3.530	0.162
Navicula radiosa var. tenella	4	1.745	0.043	6.981	0.175
Navicula radiosa.	3	1.170	0.023	7.060	0.137
Navicula spp.	10	6.466	0.206	20.944	0.836
Nitzschia acicularis.	10	11.301	0.179	49.418	0.434
Nitzschia acuta	1	0.588	0.007	7.060	0.085
Nitzschia angustata var. acuta.	6	2.886	0.069	10.472	0.230
Nitzschia denticula	2	0.549	0.016	3.491	0.100
Nitzschia dissipata	10	4.310	0.104	7.060	0.275
Nitzschia fonticola	7	3.084	0.082	10.590	0.486
Nitzschia gracilis.	7	6.733	0.115	21.179	0.563
Nitzschia spiculoides	1	0.258	0.008	3.095	0.100
Nitzschia spp..	9	11.367	0.240	45.888	0.657
Nitzschia sublinearis	1	1.177	0.010	14.120	0.124
Rhizosolenia eriensis	12	21.483	0.579	49.418	1.036
Rhizosolenia gracilis	10	13.724	0.327	41.888	1.381
Rhizosolenia statospore	7	4.981	0.087	24.709	0.279
Stephanodiscus alpinus.	2	0.549	0.020	3.491	0.137
Stephanodiscus binderanus	1	0.582	0.015	6.981	0.175
Synedra acus.	6	2.922	0.068	10.590	0.345
Synedra cyclopum.	1	2.353	0.025	28.239	0.304
Synedra filiformis.	9	8.092	0.219	17.453	0.696
Synedra parasitica.	3	1.464	0.027	10.590	0.137
Synedra ulna.	5	4.363	0.119	17.453	0.384
Tabellaria fenestrata	12	43.578	0.883	95.307	1.611
Tabellaria flocculosa	4	3.817	0.047	24.709	0.217
Tabellaria flocculosa var. linearis	7	14.077	0.477	48.869	2.269
total diatoms (75 categories) . .		2528.762	58.085		

name	number slides	average density	& % pop.	maximum density	& % pop.
Chrysococcus dokidophorus	10	8.684	0.223	17.453	0.456
Chrysococcus rufescens.	1	0.294	0.003	3.530	0.038
Chrysosphaerella longispina	7	27.841	0.541	81.187	1.950
Dinobryon cyst.	11	6.396	0.148	10.590	0.412
Dinobryon divergens	11	64.829	1.442	240.032	3.064
Dinobryon spp..	3	21.179	0.235	120.016	1.447
Mallomonas spp.	5	3.206	0.074	17.453	0.384
Mallomonas statospore	4	3.520	0.048	17.649	0.175
Mallomonas tonsurata var. alpina	1	0.291	0.012	3.491	0.139
Ochromonas spp.	9	17.926	0.461	48.869	1.923
Spiniferomonas spp.	4	2.343	0.038	10.590	0.182
Uroglenopsis americana.	2	73.879	1.538	579.448	15.146

total chrysophytes (12 categories) . .		230.389	4.760		

name	number slides	average density	& % pop.	maximum density	& % pop.
Cryptomonas erosa	1	0.291	0.011	3.491	0.137
Cryptomonas ovata	9	10.194	0.290	27.925	1.099
Cryptomonas spp..	3	1.765	0.019	10.590	0.114
Rhodomonas minuta	3	3.530	0.038	21.179	0.255
Rhodomonas minuta var. nannoplanctica . . .	10	33.357	0.613	77.657	1.306
total cryptomonads (5 categories) . .		49.137	0.972		

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total number of slides: 12 total number of taxa: 121
minimum total density: 1909.72 maximum total density: 11390.91
average total density: 4846.09

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APPENDIX III. Alpena-Fall-Tap "SUMMARY"

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  file name        F#
>DNR8004AFINN       1 .
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name	number slides	average density	& % pop.	maximum density	& % pop.
Undetermined flagellate spp.	11	57.211	1.004	162.374	2.607
total undetermined (1 categories) . .		57.211	1.004		

name	number slides	average density	& % pop.	maximum density	& % pop.
Agmenellum quadruplicatum	1	51.771	0.524	621.258	6.290
Anabaena flos-aquae	5	11.966	0.295	55.850	1.390
Anacystis incerta	9	501.993	10.717	1313.114	28.884
Anacystis thermalis	7	15.406	0.303	74.127	1.244
Gomphosphaeria lacustris.	9	595.218	12.308	1832.005	30.647
Oscillatoria spp.	2	38.688	1.105	317.649	7.712
Undetermined blue-green filament.	1	1.177	0.012	14.120	0.143
total blue-green (7 categories) . .		1216.219	25.264		

name	number slides	average density	& % pop.	maximum density	& % pop.
Ankistrodesmus spp.	3	1.458	0.044	6.981	0.249
Cosmarium spp..	1	0.294	0.004	3.530	0.043
Crucigenia spp.	1	4.707	0.048	56.478	0.572
Gloeocystis planctonica	11	37.149	0.794	102.366	1.746
Mougeotia sp. #1.	1	1.471	0.025	17.649	0.295
Oocystis spp.	5	5.441	0.159	20.944	0.521
Pediastrum boryanum	5	18.395	0.447	87.266	2.119
Scenedesmus bicellularis.	4	4.026	0.107	21.179	0.480
Scenedesmus carinatus	1	1.177	0.020	14.120	0.237
Scenedesmus quadricauda	5	10.550	0.183	56.478	0.797
Scenedesmus serratus.	2	7.060	0.107	56.478	0.945
Scenedesmus spinosus.	2	1.765	0.026	14.120	0.236

Scenedesmus spp..	10	75.644	1.413	285.920	3.454
Ulothrix spp.	2	6.455	0.097	60.008	0.725
Undetermined green filaments.	1	1.745	0.050	20.944	0.598
Undetermined green individual	1	0.258	0.012	3.095	0.139
total green (16 categories) . .		177.593	3.532		

name	number slides	average density	& % pop.	maximum density	& % pop.
Achnanthes biasolettiana.	4	1.454	0.043	6.981	0.169
Achnanthes clevei var. rostrata	2	0.549	0.019	3.491	0.139
Achnanthes exigua	6	4.105	0.077	21.179	0.256
Achnanthes spp.	8	9.318	0.261	24.435	0.608
Amphora ovalis var. affinis	5	1.745	0.056	6.981	0.240
Amphora ovalis.	9	7.037	0.126	28.239	0.341
Amphora perpusilla.	11	33.754	0.697	95.307	1.496
Amphora spp..	1	0.291	0.010	3.491	0.120
Asterionella formosa.	12	73.056	1.771	108.210	3.717
Cocconeis diminuta.	6	2.638	0.046	10.590	0.128
Cocconeis placentula var. euglypta.	2	2.056	0.028	21.179	0.256
Cyclotella comensis	12	1513.727	33.462	2710.945	44.875
Cyclotella comta.	11	15.556	0.383	24.709	0.970
Cyclotella kutzingiana.	6	3.510	0.071	14.120	0.224
Cyclotella meneghiniana	2	0.582	0.014	3.491	0.087
Cyclotella michiganiana	9	18.071	0.504	59.341	1.982
Cyclotella ocellata	11	15.701	0.346	45.888	0.839
Cyclotella operculata	2	0.879	0.020	7.060	0.120
Cyclotella pseudostelligera	6	9.331	0.238	38.397	1.096
Cyclotella spp.	1	1.548	0.069	18.571	0.831
Cyclotella stelligera	11	35.609	0.930	76.794	2.469
Cymatopleura solea.	2	0.873	0.026	6.981	0.224
Cymbella microcephala	9	7.596	0.178	17.649	0.434
Cymbella minuta	6	2.013	0.052	6.981	0.264
Cymbella minuta fo. latens.	1	0.294	0.005	3.530	0.059
Cymbella triangulum	1	0.294	0.005	3.530	0.059
Denticula tenuis var. crassula.	7	5.870	0.110	17.649	0.296
Diatoma tenue var. elongatum.	1	0.588	0.006	7.060	0.071
Fragilaria brevistriata	1	1.177	0.012	14.120	0.143
Fragilaria capucina	5	7.292	0.173	38.397	0.932
Fragilaria construens	9	40.688	0.882	120.016	3.597
Fragilaria construens var. binodis.	2	1.454	0.053	13.963	0.499
Fragilaria crotonensis.	12	379.972	8.548	737.744	13.070
Fragilaria intermedia var. fallax	5	14.626	0.217	109.426	1.108
Fragilaria leptostauron	7	5.180	0.098	21.179	0.416
Fragilaria pinnata var. lancettula.	12	162.248	3.347	388.286	7.034
Fragilaria pinnata.	12	250.957	5.105	670.676	10.388
Fragilaria spp.	3	4.258	0.119	28.239	0.554
Fragilaria vaucheriae	1	0.294	0.004	3.530	0.043
Gomphonema spp.	2	1.164	0.033	6.981	0.224
Mastogloia spp.	1	0.582	0.014	6.981	0.174
Melosira granulata var. angustissima. . . .	2	5.589	0.058	56.478	0.572

Melosira granulata.	11	136.679	3.224	271.800	10.942
Melosira islandica.	3	10.256	0.214	81.187	1.363
Navicula capitata	7	3.804	0.078	13.963	0.398
Navicula cryptocephala var. veneta.	5	4.367	0.116	17.453	0.449
Navicula cryptocephala.	5	2.905	0.047	10.590	0.178
Navicula jaernefeltii	1	0.258	0.012	3.095	0.139
Navicula pupula	1	0.294	0.003	3.530	0.036
Navicula radiosa var. tenella	6	2.330	0.070	6.981	0.249
Navicula radiosa.	5	1.752	0.039	7.060	0.112
Navicula spp.	12	18.646	0.416	38.829	0.763
Navicula stroesei	1	0.258	0.012	3.095	0.139
Neidium dubium.	1	0.291	0.007	3.491	0.085
Nitzschia acicularis.	10	29.252	0.556	102.366	1.524
Nitzschia acuta	3	2.353	0.030	17.649	0.179
Nitzschia angustata var. acuta.	9	3.477	0.082	7.060	0.249
Nitzschia confinis.	1	0.294	0.005	3.530	0.059
Nitzschia dissipata	7	4.667	0.129	14.120	0.360
Nitzschia fonticola	8	6.373	0.133	21.179	0.337
Nitzschia gracilis.	8	10.831	0.174	35.299	0.474
Nitzschia sigmoidea	1	0.258	0.012	3.095	0.139
Nitzschia spp..	12	27.194	0.582	77.657	1.385
Nitzschia sublinearis	1	0.294	0.004	3.530	0.043
Rhizosolenia eriensis	11	9.030	0.212	21.179	0.600
Rhizosolenia gracilis	9	7.311	0.165	21.179	0.498
Rhizosolenia statospore	8	7.311	0.169	14.120	0.528
Stephanodiscus alpinus.	3	1.389	0.049	6.981	0.277
Stephanodiscus niagarae	1	0.258	0.012	3.095	0.139
Synedra acus.	10	7.612	0.157	24.709	0.415
Synedra filiformis.	9	10.508	0.248	24.435	0.600
Synedra parasitica.	4	2.307	0.058	10.472	0.360
Synedra spp..	2	0.810	0.028	6.190	0.277
Synedra ulna.	5	2.912	0.081	13.963	0.339
Tabellaria fenestrata	11	39.049	0.793	88.247	1.695
Tabellaria fenestrata var. geniculata . . .	1	0.294	0.005	3.530	0.059
Tabellaria flocculosa	6	4.680	0.110	20.944	0.673
Tabellaria flocculosa var. linearis	5	8.370	0.258	48.869	1.571
total diatoms (78 categories) . .		3012.193	66.505		

name	number slides	average density	& % pop.	maximum density	& % pop.
Chrysococcus dokidophorus	8	5.850	0.140	17.649	0.396
Chrysococcus rufescens.	5	3.788	0.100	17.453	0.424
Chrysosphaerella longispina	4	7.645	0.099	45.888	0.554
Dinobryon cyst.	11	10.720	0.246	17.649	0.498
Dinobryon divergens	12	66.462	1.812	174.533	5.612
Dinobryon spp..	4	6.177	0.079	38.829	0.413
Mallomonas spp.	4	2.337	0.062	13.963	0.480
Mallomonas statospore	3	2.023	0.031	17.649	0.179
Ochromonas spp.	9	9.936	0.240	35.299	0.592
Spiniferomonas spp.	2	0.585	0.015	3.530	0.132
total chrysophytes (10 categories) . .		115.523	2.824		

name	number slides	average density	average % pop.	maximum density	maximum % pop.
Cryptomonas ovata	10	7.785	0.207	17.649	0.600
Cryptomonas spp..	3	1.765	0.023	7.060	0.118
Rhodomonas minuta	4	6.177	0.069	49.418	0.500
Rhodomonas minuta var. nannoplanctica . . .	9	24.559	0.559	60.008	1.321
total cryptomonads (4 categories) . .		40.285	0.858		

name	number slides	average density	average % pop.	maximum density	maximum % pop.
Gymnodinium helveticum.	1	0.258	0.012	3.095	0.139
total dinoflagellates (1 categories) . .		0.258	0.012		

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total number of slides: 12 total number of taxa: 117

minimum total density: 2234.71 maximum total density: 9876.59

average total density: 4619.29

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APPENDIX III. Alpena-Winter-Lake "SUMMARY"

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file name        F#
>DNR8105AWOUT     1
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name	number slides	average density	& % pop.	maximum density	& % pop.
Undetermined flagellate spp.	6	70.128	15.282	102.140	38.824
total undetermined (1 categories) . .		70.128	15.282		

name	number slides	average density	& % pop.	maximum density	& % pop.
Anacystis thermalis	1	2.327	0.304	13.963	1.826
Gomphosphaeria lacustris.	1	35.488	3.684	212.930	22.101
total blue-green (2 categories) . .		37.815	3.988		

name	number slides	average density	& % pop.	maximum density	& % pop.
Cosmarium spp..	1	0.582	0.076	3.491	0.457
Gloeocystis planctonica	2	5.236	0.760	20.944	2.740
Undetermined green individual	2	2.909	0.469	13.963	2.210
total green (3 categories) . .		8.727	1.305		

name	number slides	average density	& % pop.	maximum density	& % pop.
Achnanthes clevei var. rostrata	1	0.582	0.076	3.491	0.457
Achnanthes exigua	1	0.516	0.122	3.095	0.730
Achnanthes lanceolata var. omissa	1	0.582	0.076	3.491	0.457
Achnanthes spp.	3	2.195	0.569	6.190	2.353
Amphora ovalis.	1	0.516	0.196	3.095	1.176
Amphora perpusilla.	2	2.195	0.544	6.981	2.353
Asterionella formosa.	6	18.408	3.412	34.907	5.882
Cocconeis diminuta.	1	0.516	0.122	3.095	0.730
Cyclotella comensis	6	80.798	14.671	171.042	31.387
Cyclotella comta.	3	4.588	0.867	13.963	2.210
Cyclotella meneghiniana	1	1.745	0.276	10.472	1.657
Cyclotella michiganiana	2	1.098	0.256	3.491	1.176
Cyclotella ocellata	6	42.513	7.500	73.304	9.589
Cyclotella stelligera	5	43.370	6.461	101.229	16.022
Cymbella microcephala	1	0.516	0.122	3.095	0.730
Cymbella minuta	1	0.582	0.092	3.491	0.552
Denticula tenuis var. crassula.	1	0.516	0.196	3.095	1.176
Fragilaria crotonensis.	3	7.497	1.383	38.397	6.667
Fragilaria pinnata var. lancettula.	1	0.582	0.076	3.491	0.457
Fragilaria pinnata.	2	1.098	0.297	3.491	1.176
Fragilaria spp.	1	0.582	0.101	3.491	0.606
Fragilaria vaucheriae	1	0.516	0.122	3.095	0.730
Melosira granulata.	3	10.142	1.596	27.925	3.650
Navicula cryptocephala.	1	1.032	0.243	6.190	1.460
Navicula radiosa var. tenella	2	1.164	0.136	3.491	0.457
Navicula spp.	1	0.582	0.076	3.491	0.457
Nitzschia acicularis.	2	1.098	0.223	3.491	0.730
Nitzschia confinis.	1	0.582	0.060	3.491	0.362
Nitzschia fonticola	3	2.195	0.470	6.981	1.176
Nitzschia spp..	2	1.745	0.294	6.981	1.212
Rhizosolenia eriensis	2	4.325	0.789	15.476	3.650
Synedra acus.	2	2.327	0.273	6.981	0.913
Synedra filiformis.	6	24.928	4.475	55.713	13.139
Synedra spp..	3	5.236	0.866	20.944	3.636
Tabellaria fenestrata	4	26.180	4.069	101.229	17.576
Tabellaria flocculosa	1	1.164	0.202	6.981	1.212
Tabellaria flocculosa var. linearis	3	4.588	0.639	20.944	2.740
total diatoms (37 categories) . .		298.794	51.950		

name	number slides	average density	& % pop.	maximum density	& % pop.
Dinobryon divergens	3	12.217	1.615	34.907	4.566
Dinobryon spp..	2	1.745	0.262	6.981	1.212
Kephyrion spp..	1	0.516	0.122	3.095	0.730
Monochrysis aphanaster.	3	2.843	0.395	6.981	0.913
Ochromonas spp.	6	22.678	3.622	48.869	5.936
total chrysophytes (5 categories) . .		39.999	6.017		

name	number slides	average density	& % pop.	maximum density	& % pop.
Cryptomonas ovata	6	19.583	2.872	45.379	4.710
Cryptomonas spp..	5	25.532	3.950	76.794	12.155
Rhodomonas minuta var. nannoplanctica . . .	6	102.633	14.544	289.724	30.072
total cryptomonads (3 categories) . .		147.748	21.366		

name	number slides	average density	& % pop.	maximum density	& % pop.
Gymnodinium spp..	1	0.582	0.092	3.491	0.552
total dinoflagellates (1 categories) . .		0.582	0.092		

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total number of slides: 6 total number of taxa: 52

minimum total density: 263.09 maximum total density: 963.42

average total density: 603.79

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APPENDIX III. Alpena-Winter-Tap "SUMMARY"

file name	F#
>DNR8106AWINN	1
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name	number slides	average density	& % pop.	maximum density	& % pop.
Undetermined flagellate spp.	6	40.054	6.962	58.808	14.961
total undetermined (1 categories) . .		40.054	6.962		

name	number slides	average density	& % pop.	maximum density	& % pop.
Anabaena flos-aquae	1	6.981	1.667	41.888	10.000
Anacystis thermalis	1	1.032	0.262	6.190	1.575
Gomphosphaeria lacustris.	1	48.869	5.091	293.215	30.545
Oscillatoria bornetii	1	16.871	1.758	101.229	10.545
total blue-green (4 categories) . .		73.754	8.778		

name	number slides	average density	& % pop.	maximum density	& % pop.
Gloeocystis planctonica	1	2.327	0.321	13.963	1.923
Oocystis spp.	2	2.909	0.622	13.963	3.252
Undetermined green individual	1	4.654	0.641	27.925	3.846
total green (3 categories) . .		9.890	1.584		

name	number slides	average density	& % pop.	maximum density	& % pop.
Achnanthes clevei var. rostrata	1	1.164	0.132	6.981	0.791
Achnanthes lanceolata var. dubia.	1	0.582	0.066	3.491	0.395
Achnanthes spp.	5	4.588	0.819	10.472	1.626
Amphora perpusilla.	1	0.582	0.139	3.491	0.833
Asterionella formosa.	6	20.033	3.134	41.888	5.000
Cyclotella antiqua.	1	0.582	0.136	3.491	0.813
Cyclotella comensis	6	95.959	16.595	226.893	25.692
Cyclotella comta.	4	3.875	0.680	9.285	2.362
Cyclotella ocellata	6	29.473	4.499	52.360	6.504
Cyclotella pseudostelligera	1	0.582	0.066	3.491	0.395
Cyclotella stelligera	6	57.068	8.663	125.664	17.308
Denticula tenuis var. crassula.	1	0.582	0.061	3.491	0.364
Fragilaria brevistriata	1	0.582	0.139	3.491	0.833
Fragilaria construens	3	4.072	0.633	10.472	1.626
Fragilaria crotonensis.	5	41.481	6.735	94.248	12.981
Fragilaria leptostauron	1	4.072	0.461	24.435	2.767
Fragilaria pinnata var. lancettula.	2	8.727	1.134	45.379	5.138
Fragilaria pinnata.	6	8.913	1.641	18.571	4.724
Melosira granulata.	4	17.442	2.633	52.360	7.087
Navicula cryptocephala.	1	0.516	0.131	3.095	0.787
Navicula spp.	4	2.261	0.413	3.491	0.813
Nitzschia acicularis.	4	5.236	0.892	13.963	1.667
Nitzschia confinis.	1	0.582	0.066	3.491	0.395
Nitzschia fonticola	1	0.582	0.061	3.491	0.364
Nitzschia spp..	4	3.491	0.488	6.981	0.962
Rhizosolenia eriensis	6	8.079	1.157	17.453	1.976
Rhizosolenia gracilis	3	1.745	0.335	3.491	0.833
Synedra acus.	2	2.909	0.475	10.472	1.667
Synedra filiformis.	6	21.844	3.504	41.888	5.000
Synedra spp..	2	1.164	0.219	3.491	0.833
Tabellaria fenestrata	3	12.788	2.358	45.379	7.087
Tabellaria flocculosa	1	1.164	0.160	6.981	0.962
Tabellaria flocculosa var. linearis	3	7.497	0.937	38.397	4.000
total diatoms (33 categories) . .		370.210	59.559		

name	number slides	average density	& % pop.	maximum density	& % pop.
Dinobryon divergens	5	26.762	4.349	45.379	8.333
Monochrysis aphanaster.	1	0.582	0.136	3.491	0.813
Ochromonas spp.	5	13.831	2.470	24.435	5.691
total chrysophytes (3 categories) . .		41.174	6.954		

name	number slides	average density	& % pop.	maximum density	& % pop.
Cryptomonas ovata	6	13.249	2.128	20.944	2.885
Cryptomonas spp..	6	27.212	3.923	94.248	12.981
Rhodomonas minuta var. nannoplanctica . . .	6	58.946	10.033	87.266	20.833
total cryptomonads (3 categories) . .		99.406	16.083		

name	number slides	average density	& % pop.	maximum density	& % pop.
Gymnodinium spp..	1	0.582	0.080	3.491	0.481
total dinoflagellates (1 categories) . .		0.582	0.080		

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total number of slides: 6 total number of taxa: 48

minimum total density: 393.09 maximum total density: 959.93

average total density: 635.07

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